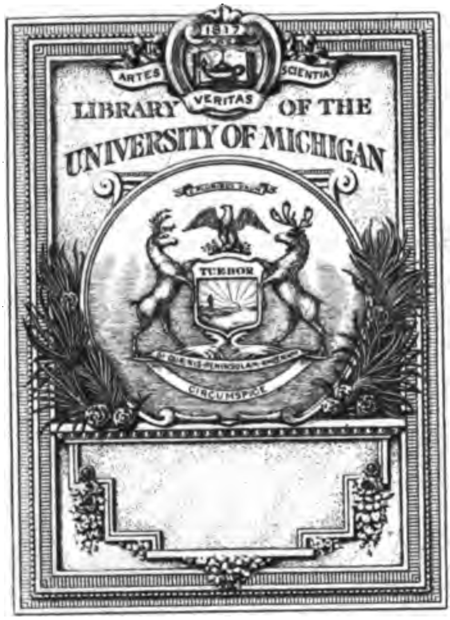
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PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XXXV. JANUARY, 1896. No. 150.

TABLE OF CONTENTS.

☞ It is requested that the receipt of this number be acknowledged.

☞ In order to secure prompt attention it is requested that all correspondence be addressed simply "To the Secretaries of the American Philosophical Society, 104 S. Fifth St., Philadelphia."

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EXTRACT FROM THE LAWS.

CHAPTER XII.

OF THE MAGELLANIC FUND.

SECTION 1. John Hyacinth de Magellan, in London, having in the year 1786 offered to the Society, as a donation, the sum of two hundred guineas, to be by them vested in a secure and permanent fund, to the end that the interest arising therefrom should be annually disposed of in premiums, to be adjudged by them to the author of the best discovery, or most useful invention, relating to Navigation, Astronomy, or Natural Philosophy (mere natural history only excepted); and the Society having accepted of the above donation, they hereby publish the conditions, prescribed by the donor and agreed to by the Society, upon which the said annual premiums will be awarded.

CONDITIONS OF THE MAGELLANIC PREMIUM.

1. The candidate shall send his discovery, invention or improvement, addressed to the President, or one of the Vice-Presidents of the Society, free of postage or other charges; and shall distinguish his performance by some motto, device, or other signature, at his pleasure. Together with his discovery, invention, or improvement, he shall also send a sealed letter containing the same motto, device, or signature, and subscribed with the real name and place of residence of the author.

2. Persons of any nation, sect or denomination whatever, shall be admitted as candidates for this premium.

3. No discovery, invention or improvement shall be entitled to this premium, which hath been already published, or for which the author hath been publicly rewarded elsewhere.

4. The candidate shall communicate his discovery, invention or improvement, either in the English, French, German, or Latin language.

5. All such communications shall be publicly read or exhibited to the Society at some stated meeting, not less than one month previous to the day of adjudication, and shall at all times be open to the inspection of such members as shall desire it. But no member shall carry home with

PROCEEDINGS

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AMERICAN PHILOSOPHICAL SOCIETY

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Vol. XXXV.

JANUARY TO DECEMBER, 1896.

PHILADELPHIA:
THE AMERICAN PHILOSOPHICAL SOCIETY,
1896.

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XXXV. JANUARY, 1896. No. 150.

Stated Meeting, January 3, 1896.

Mr. W. V. McKEAN in the Chair.

Present, 27 members.

Reports of the Clerks and Judges of the election were read and the report of the election was submitted:

President.

Frederick Fraley.

Vice-Presidents.

E. Otis Kendall, J. P. Lesley, Wm. Pepper.

Secretaries.

George F. Barker, George H. Horn, Persifor Frazer, Patterson Du Bois.

Curators.

J. Cheston Morris, R. Meade Bache, Benj. S. Lyman.

Treasurer.

J. Sergeant Price.

Councilors.

Wm. A. Ingham, Chas. S. Wurts, Robert Patterson, Henry Hartshorne, Isaac J. Wistar, in place of Richard Vaux, deceased.

On motion, the thanks of the Society were tendered to Judge Edmunds and his associates for their services on the board of election.

Letters of envoy from the Geological Survey of India, Calcutta; Naturwissenschaftlichem Vereine, Osnabrück, Prussia; Society of Antiquaries, London, Eng.; Direccion General de Estadistica, Mexico, Mex.

Letters of acknowledgment from the Linnean Society of N. S. Wales, Sydney (143, 146); Geological Survey of India, Calcutta (147); M. G. Tschermak, Vienna, Austria (147); Naturwissenschaftl. Gesellschaft "Isis," Dresden, Saxony (147); Società Italiana d'Igiene, Milan, Italy (143, 146); Società Africana d'Italia, Naples, Italy (147); R. Accademia di Scienze, Lettere, etc., Padua, Italy (143); R. Comitato Geologico d'Italia, Rome (147); Dr. Charles S. Wurts, Philadelphia (147); California Academy of Sciences, San Francisco (144, 145).

Accessions to the Library were reported from the Schweiz. Naturfor. Gesellschaft, Schaffhausen; Thüringische Geschichte und Altertumskunde, Jena, Germany; Mr. Horatio Hale, Ottowa, Canada; Dr. Samuel A. Green, Boston, Mass.; Dr. C. A. M. Fennell, Cambridge, Mass.; Prof. E. J. James, Mr. B. S. Lyman, Philadelphia; U. S. National Museum, U. S. Dept. of Agriculture, Washington, D.C.; Academy of Sciences, Department of Public Works, Chicago, Ill.; Agricultural Experiment Station, Ames, Ia.; Dr. Jesus Diaz de Leon, Aguascalientes, Mexico; Sociedad Cientifica, "Antonio Alzate," Mexico, Mex.

The stated business of the meeting being the nomination of Librarian, J. Sergeant Price nominated George H. Horn, and E. D. Cope nominated Benj. S. Lyman.

Prof. Cope made a verbal communication on certain

types of Saurians in completion of a former paper on the same subject.

Pending nominations 1332 to 1334 were read.

Mr. Wm. A. Ingham moved to amend Chapter viii, Section 3 of the Laws, by striking out "from 10 A.M. to 1 P.M.," and inserting "at such hours as the Society may by resolution from time to time direct." Laid over under the laws.

The Judges of election reported the receipt of a paper questioning the eligibility of a candidate. As they deemed the question beyond their jurisdiction the paper was referred to the Society for action. On motion, the President was requested to appoint a committee of three to investigate and report upon it.

After reading the rough minutes, the Society was adjourned by the presiding member.

Stated Meeting, January 17, 1896.

President, Mr. FRALEY, in the Chair.

Present, 36 members.

Correspondence was submitted as follows:

Invitation from the Société Impériale Russe de Geographie, St. Petersburg, to attend the Fiftieth Anniversary of its foundation, February 2 (January 21), 1896.

Letter from Mr. Thomas Meehan, offering to take in hand the labeling of the South American plants from Dr. Barton's collection belonging to the Society, and suggesting that they be deposited in the herbarium of the Academy of Natural Sciences, Philadelphia.

A communication from the Librarian of the University of Virginia, Charlottesville, stating that their complete set of the A. P. S. *Proceedings* was destroyed by fire, October 27, 1895, was referred to Secretaries with power to act.

Letters of acknowledgment (148) were received from the Wag-

ner Free Institute, Franklin Institute, Historical Society of Pennsylvania, College of Physicians, Numismatic and Antiquarian Society, Gen. I. J. Wistar, Hon. Mayer Sulzberger, Profs. John Ashhurst, Jr., F. A. Genth, Jr., H. D. Gregory, James MacAlister, James Tyson, M.D., Drs. John H. Brinton, W. C. Cattell, Samuel G. Dixon, Ed. A. Foggo, George H. Horn, Morris Longstreth, Charles A. Oliver, Charles Schäffer, D. K. Tuttle, William H. Wahl, Messrs. R. Meade Bache, Henry C. Baird, George Tucker Bispham, Lorin Blodget, Arthur E. Brown, Jacob B. Eckfeldt, Benjamin Smith Lyman, Theodore D. Rand, J. G. Rosengarten, F. D. Stone, Philadelphia; Mr. Heber S. Thompson, Pottsville, Pa.; Dr. W. H. Appleton, Swarthmore, Pa.; Dr. John Curwen, Warren, Pa.; Prof. J. T. Rothrock, West Chester, Pa.; Prof. Ira Remsen, Baltimore, Md.; University of Virginia, Prof. J. W. Mallet, M.D., Charlottesville.

Accessions to the Library were reported from the Institut Egyptien, Cairo; Académie Imp. des Sciences, St. Petersburg, Russia; Friesch Genootschap van Geschied, etc., Leuwarden, Netherlands; Académie des Sciences, Cracow, Austria; K. K. Geologische Reichsanstalt, Vienna, Austria; Gesellschaft für Anthropologie, Ethnologie, etc., Berlin, Prussia; Gartenbauverein, Darmstadt, Germany; K. Sächs. Gesellschaft der Wissenschaften, Leipzig; Nassauischen Vereine für Naturkunde, Wiesbaden, Prussia; Biblioteca N. C., Firenze, Italia; Société de Geographie, Lille, France; Redaction *Cosmos*, Le Mqs. de Nadaillac, Paris, France; Meteorological Office, R. Geographical Society, Editors of *Nature*, R. Microscopical Society, Editors of *The Geological Magazine*, London, Eng.; Agricultural Experiment Station, Durham, N. H.; Mass. Historical Society, Boston, Mass.; Astronomical Observatory of Harvard College, Cambridge, Mass.; Essex Institute, Salem, Mass.; R. I. Historical Society, Providence; Editors of *The American Journal of Science*, Yale University, New Haven, Conn.; Editor of *The Popular Science Monthly*, Academy of Sciences, Editor of *The World*, New York, N. Y.; College of Pharmacy, Franklin Institute, Amer. Society for the Extension of University

Teaching, Mr. Wharton Barker, Drs. Persifor Frazer, Edmund J. James, Hon. Samuel W. Pennypacker, Philadelphia; Oberlin College Library, Oberlin, O.

A photograph for the Society's Album was received from Mr. Thomas Clarke, New York, N. Y.

The death of Mr. Henry Hazlehurst, of Philadelphia, on January 11, 1896, æt. 49, was announced, and the President was requested to appoint a member to prepare an obituary notice.

Prof. Cope read an obituary notice of Prof. John A. Ryder.

The stated business of the meeting being the choosing of a Librarian, a ballot was taken, and on count of the vote the Tellers announced the election of George H. Horn.

The choosing of Standing Committees being in order, Mr. Prime moved that they be appointed by the President. Carried unanimously.

The Special Committee appointed to inquire into the eligibility of candidates and electors at the late election made a report which was received and the Committee discharged.

Prof. Hilprecht presented his paper on "Old Babylonian Inscriptions," which on motion was referred to a Special Committee to examine and report. The President appointed Talcott Williams, Patterson DuBois and J. Sergeant Price, the Committee.

Pending nominations Nos. 1332 to 1334 and new nominations Nos. 1335 to 1345 were read.

On motion of Dr. Morris, the nominations of non-residents were referred to Council.

On motion of Mr. Price, the Society authorized the Treasurer to receive payment for loan of the city of Philadelphia now due and payable.

The letter of Mr. Meehan regarding South American plants in our cabinet was referred to the Curators to report at the next meeting.

On motion of Dr. Frazer, amended by Dr. Brinton, the Secretaries were directed to print a revised list of surviving members with their addresses.

The amendment to the Laws offered at last meeting was considered. The Librarian gave proof of advertisement.

By the requisite vote, Chap. viii, Sec. 3, was amended by striking out "10 A.M. to 1 P.M.," and inserting "at such hours as the Society may fix by resolution from time to time."

The rough minutes were then read, and the Society was adjourned by the President.

Stated Meeting, February 7, 1896.

Present, 16 members.

President, Mr. FRALEY, in the Chair.

Correspondence was submitted as follows:

A letter from Prof. George H. Smith, Los Angeles, Cal., expressing grateful appreciation of the honor conferred upon him by the Society, in publishing his essay, and presenting him with two hundred and fifty copies.

A letter from Mr. Benjamin Sharp, Philadelphia, requesting for the Academy of Natural Sciences the privilege of having a microscopical examination made of two pieces of Jade, deposited in the Museum of the Academy. On motion, this request was referred to the Curators.

Acknowledgments were received from the Institut Egyptien, Cairo (147); K. K. Bergakademie, Leoben, Austria (92–107, 110, 111, 113–120, 125–133, 135–147); K. K. Zoolog-botanische Gesellschaft, Vienna, Austria (147); Schlesische Gesellschaft für vaterl. Cultur, Breslau, Prussia (147); Naturhistorische Gesellschaft, Hannover, Prussia (147); Naturhistorische Gesellschaft, Nürnberg, Bavaria (147); Verein für Naturkunde, Offenbach-a.-M., Germany (143, 146, 147); K. Geodätisches Institut, Potsdam, Prussia (147); Biblioteca N. C., Firenze, Italia (147); R. Istituto di Scienze, etc., Milan, Italy (143, 146); Observatorio di Torino, Torino, Italia (147, and *Trans.*, xviii, 2); Prof. G. Sergi, Rome, Italy (147); Commission des Annales des Mines

(147 and *Trans.*, xviii, 2); Musée Guimet, Paris, France (147); Literary and Philosophical Society, Liverpool, Eng. (147, and *Trans.*, xviii, 2); Mass. Historical Society, Boston, Mass. (147); Prof. Edward S. Morse, Salem, Mass. (147); Newberry Library, Chicago, Ill. (147); Museo Nacional, Buenos Ayres, Argentine Republic (147).

Acknowledgments (148) were received from Dr. Alfred R. C. Selwyn, Geological Survey, Ottawa, Canada; Laval University, Hon. J. M. Le Moine, Quebec, Canada; Bowdoin College Library, Brunswick, Me.; N. H. Historical Society, Concord; Boston Society of Natural History, Mass.; Historical Society, Boston Athenæum, Mass. Institute of Technology, State Library of Massachusetts, Dr. Samuel A. Green, Boston, Mass.; Museum of Comparative Zoology, Profs. Alexander Agassiz, N. W. Goodwin, F. W. Putnam, Dr. Justin Winsor, Mr. Robert N. Toppan, Cambridge, Mass.; Essex Institute, Prof. Edward S. Morse, Salem, Mass.; Prof. Elihu Thomson, Swampscot, Mass.; Marine Biological Laboratory, Woods Holl, Mass.; American Antiquarian Society, Worcester, Mass.; Brown University, Providence Franklin Society, R. I. Historical Society, Providence; Mr. George F. Dunning, Farmington, Conn.; Conn. Historical Society, Hartford; Prof. H. A. Newton, New Haven, Conn.; Prof. James Hall, Albany, N. Y.; Society of Natural Science, Buffalo, N. Y.; Prof. Edward North, Clinton, N. Y.; Profs. J. M. Hart, W. T. Hewett, Ithaca, N. Y.; Historical Society, N. Y. Hospital, Columbia College, N. Y. Academy of Medicine, N. Y. Academy of Science, Astor Library, Amer. Museum of Natural History, Hon. James C. Carter, Messrs. Thos. C. Clarke, James Douglas, Profs. Isaac H. Hall, J. J. Stevenson, New York, N. Y.; Vassar Brothers' Institute, Poughkeepsie, N. Y.; Geological Society of America, Rochester, N. Y.; Prof. W. Le Conte Stevens, Troy, N. Y.; Oneida Historical Society, Utica, N. Y.; U. S. Military Academy, West Point, N. Y.; Free Public Library, Jersey City, N. J.; Prof. Robert W. Rogers, Madison, N. J.; Natural History Society, Trenton, N. J.; Dr. R. H. Alison, Ardmore, Pa.;

Prof. Martin H. Boyé, Coopersburg, Pa.; Amer. Academy of Medicine, Dr. Traill Green, Prof. J. W. Moore, Rev. Thos. C. Porter, Easton, Pa.; Mr. John Fulton, Johnstown, Pa.; Prof. L. B. Hall, Haverford, Pa.; Linnean Society, Lancaster, Pa.; Rev. J. W. Robins, Merion, Pa.; Library Company, Prof. H. V. Hilprecht, Drs. Edward Foggo, Persifor Frazer, Sara Y. Stevenson, Messrs. H. Clay Trumbull, Joel Cook, Patterson Du Bois, Robert Patterson, Benjamin Sharp, Charles Stewart Wurts, Ellis Yarnall, Philadelphia, Pa.; Rev. F. A. Muhlenberg, Reading, Pa.; Mr. Thos. S. Blair, Tyrone, Pa.; Mr. Philip P. Sharples, West Chester, Pa.; Wyoming Historical Society, Wilkesbarre, Pa.; Col. Henry A. Du Pont, Winterthur, Del.; Maryland Institute, Baltimore, Md.; Mr. T. L. Patterson, Cumberland, Md.; U. S. Artillery Staff, Fort Monroe, Va.; Hon. J. R. Tucker, Lexington, Va.; Mr. Jed. Hotchkiss, Staunton, Va.; Ga. Historical Society, Savannah; Cincinnati Observatory, Cincinnati, O.; Ohio State Archæological and Historical Society, Columbus, O.; Editors of *Journal of Comparative Neurology*, Granville, O.; Oberlin College, Oberlin, O.; Prof. J. L. Campbell, Crawfordsville, Ind.; University of Illinois, Champaign, Ill.; Field Columbian Museum, Newberry Library, Chicago, Ill.; Geological Survey of Missouri, Jefferson City, Mo.; State Historical Society of Wisconsin, University of Wisconsin, Madison; Ia. Masonic Library, Cedar Rapids; Academy of Natural Sciences, Davenport, Ia.; State Historical Society, Iowa City, Ia.; Editor of the *Kansas University Quarterly*, Lawrence, Kans.; Academy of Science, Washburn College, Topeka, Kans.; University of California, Prof. Joseph Le Conte, Berkeley, Cal.; Lick Observatory, Mt. Hamilton, Cal.; State Mining Bureau, Cal. Historical Society, Prof. George Davidson, San Francisco, Cal.; Prof. J. C. Branner, Stamford University, Cal.; Agricultural Experiment Stations, Kingston, R. I.; Storrs, Conn.; Experiment, Ga.; Knoxville, Tenn.; Agricultural College, Mich.; Manhattan, Kans.; Lincoln, Neb.; Fort Collins, Colo.; Tucson, Arizona.

Accessions to the Library were reported from the Asiatic Society of Japan, Yokohama; Société Physico-Mathématique, Kasan, Russia; Société Imp. des Naturalistes, Moscow, Russia; Société des Naturalistes de la Nouvelle Russie, Odessa; Comité Géologique, Imp. Russian Geographical Society, St. Petersburg; Statistika Central Byråns, Stockholm, Sweden; Société R. des Antiquaires du Nord, Copenhagen, Denmark; Académie R. des Sciences, etc., Etat Indépendant du Congo, Bruxelles, Belgique; Société Hongroise de Géographie, Budapest; K. K. Zool.-botanische Gesellschaft, Oesterreichische Touristen-Club, Vienna; Physiologische Gesellschaft, Verein zur Beförderung des Gartenbaues, Berlin, Prussia; K. Sächs. Meteorologisches Institut, Chemnitz; Naturforschende Gesellschaft, Emden, Prussia; Naturforschende Gesellschaft, Freiburg-i.-B., Baden; Deutsche Seewarte, Hamburg, Germany; M. Henri de Saussure, Geneva, Switzerland; Société des Sciences Phys. et Naturelles, Bordeaux, France; Société Historique, Litteraire etc., du Clur, Bourges, France; Société N. des Sciences Nat. et Mathématiques, Cherbourg, France; Société de Borda, Dax, France, ; Union Geographique du Nord de la France, Douai, France; Société des Sciences Nat. et Archæologique de la Creuse, Guéret, France; Société Languedocienne de Geographie, Montpellier, France; Sociétés Géologique de France, de Géographie, de l'Enseignement, de Physique, d'Anthropologie, Musée Guimet, Directeur de la Rédaction *Melusine*, Museum d'Histoire Naturelle, Ministre des Travaux Publics, Paris, France; M. Ed. Piette, Rumigny, France; Société des Antiquaires de la Morinie, St. Omer, France; Société de Géographie, Toulouse, France; R. Academia de la Historia, Madrid, Spain; Philological Society, Cambridge, Mass.; R. Astronomical Society, Royal Society, London, Eng.; Geological Society, Manchester, Eng.; R. Society of Antiquaries of Ireland; Commissioner of Public Records, Chief of Bureau of Statistics of Labor, Mass. Institute of Technology, Boston, Mass.; Museum of Comp. Zoölogy, Harvard University, Cambridge, Mass.; Travelers'

Insurance Co., Hartford, Conn.; Meteorological Observatory, Amer. Mathematical Society, Amer. Institute of Electrical Engineers, Amer. Geographical Society, New York, N. Y.; Mr. R. P. Potts, Camden, N. J.; Free Public Library, Jersey City, N. J.; Penna. Board of Charities and Committee on Lunacy, Harrisburg; Engineers' Club, Maritime Exchange, Hon. G. F. Edmunds, Dr. Walter M. James, Philadelphia; Johns Hopkins University, Editors of *Chemical Journal* and *American Journal of Philology*, Baltimore, Md.; Anthropological Society, Smithsonian Institution, Departments of the Interior and State, Washington, D. C.; Academy of Science, St. Louis, Mo.; Editors of *Journal of Comparative Neurology*, Granville, O.; College Library, Oberlin, O.; State Board of Health, Nashville, Tenn.; University of California, Berkeley; Field Columbian Museum, Academy of Sciences, Historical Society, Chicago, Ill.; Geological and Natural History Survey of Minnesota, St. Paul; Agricultural Experiment Stations, Amherst, Mass.; Ithaca, N. Y.; State College, Pa.; Newark, N. J.; Lafayette, Ind.; Minneapolis, Minn.; Observatorio Meteorl. Central, Observatorio Astron. N. de Tacubaya, Mexico, Mex.; Observatorio Meteorl. Central del estado de Veracruz Llave, Xalapa, Mex.

A photograph for the Society's Album was received from Dr. Edward A. Foggo, Philadelphia.

Mr. Sachse presented two pictures. The one is a copy of a pencil sketch of the Hall of the Philadelphia Academy, in which this Society held its meetings for many years, drawn to scale by Pierre E. du Simitière. The other picture is a print published in 1790 of the present Hall of the Society as it was at that time.

On motion, the thanks of the Society were voted to Mr. Sachse for his gift. The Special Committee on Prof. Hilprecht's Paper on Cuneiform Inscriptions reported favorably, and the Publication Committee also reported recommending its publication. On motion, the paper was ordered to be published.

On behalf of the Curators, Dr. Morris reported that they

had met and considered the letter of Mr. Meehan with reference to the botanical collections of Lewis and Clark, and other collections such as those of Muhlenberg, Burton, Bettors and Short, now in the museum of the Society, and had passed a resolution recommending their deposit on the usual conditions with the Academy of Natural Sciences; but after further examination of them Mr. Meehan had written, stating that unless they could be given to the Academy they had better remain where they now are, and expressing a desire that the Society should at some future time establish a herbarium of its own, to which he thought the Academy of Natural Sciences would gladly contribute some of its duplicates.

Dr. Morris moved the discharge of the Curators from further consideration of the matter at present.

The death was announced of the Rev. William H. Furness, D.D., on January 30, 1896, æt. 93; and the President was requested to appoint a member to prepare an obituary notice.

The President announced that he had appointed Dr. Brinton to prepare the obituary of Henry Hazlehurst, and F. D. Stone that of William John Potts, and that the appointments had been accepted.

Prof. Cope made a communication illustrating by blackboard sketches the structure of heads of certain Cetaceans.

Pending nominations 1332 to 1342 and 1344 and 1345 were read.

Dr. Brinton asked the decision of the Chair as to whether any action could be taken on the report of the Special Committee which was read at the last meeting.

The President decided that the matter was finally concluded.

Dr. Green moved that the report of the Committee be entered in full on the minutes. Adopted.

There being no further business, the rough minutes were read and the Society adjourned by the President.

Stated Meeting, February 21, 1896.

Present, 51 members.

The President, Mr. **Fraley**, in the Chair.

After the meeting had been called to order, Dr. Frazer moved that the regular order of business be suspended until after the demonstration of the Röntgen ray, and that the President be authorized at his discretion at the close of the discussion to declare the meeting adjourned until February 28.

The motion having been carried by the requisite affirmative vote, Dr. Goodspeed was given the floor, and presented the entire subject in detail.

Prof. Houston followed with a discussion of the subject from its electrical side.

Mr. Sachse followed in its photographic relations, and gave his experiences with different styles of plates.

Prof. Robb stated that he had in his laboratory repeated the Röntgen experiments and found that a Crooke's tube was not essential.

Mr. Carbutt gave his experience in the manufacture of plates, dwelling on the probable utility of those with a celluloid basis.

Mr. Jos. Wharton exhibited a tube containing argon, and showed its action under the induction current.

Dr. Pepper exhibited photographs from Prof. John Cox, of McGill University, one of which illustrated the method of obtaining a confirmation of the suspected position of a bullet between the tibia and fibula.

The papers of these speakers will be found in the ***Proceedings, in extenso***, together with the discussion which ensued.

Dr. Frazer moved the thanks of the Society to the Electric Storage Battery Renting Co. for their loan of a storage battery for the present demonstration.

At 10.30 the President declared the meeting adjourned until Friday, February 28.

Adjourned Meeting, February 28, 1896.

The Vice-President, Dr. PEPPER, in the Chair.

Letters of envoy from the Verein für Schlesische Insektenkunde, Breslau, Prussia; K. Sächsische Gesellschaft der Wissenschaften, Leipzig; Société des Sciences Physiques et Naturelles, Bordeaux, France; Université de Lyon, France; Faculté des Sciences, Marseilles, France; Meteorological Office, British Association for Advancement of Science, R. Statistical Society, London, Eng.; Field Columbian Museum, Chicago, Ill.; State Librarian, Washington, D. C.

Letters of acknowledgment were received from the South African Philosophical Society, Cape Town (143, 146, 147); Royal Society of Victoria (143, 146); Royal Mint, Melbourne, Australia (143, 146); K. Norske Videnskabers Selskab, Throndhjein, Norway (147); Royal Society of Sciences, Upsal, Sweden (143, 146, 147, and *Trans.*, xviii, 2); R. Danske Videnskabernes Selskab, Copenhagen (147, and *Trans.*, xviii, 2); Verein der Freunde der Naturgeschichte, Mecklenburg, Germany (147); R. Istituto Lombardo di Scienze e Lettere, Milan, Italy (147); Accademia R. delle Scienze, Torino, Italia (147); Académie des Sciences et Belles-Lettres, Angers, France (143, 147); Société N. des Sciences Nat. et Mathématiques, Cherbourg, France (143, 144, 146); Université de Lyon, France (147); Nova Scotia Society of Natural Science, Halifax (148); Public Library, Boston, Mass. (148); Harvard University, Cambridge, Mass. (148); Free Public Library, New Bedford, Mass. (148); Mercantile Library (148), Mrs. Helen Abbott Michael (148), Mr. William A. Ingham (147, 148), Hon. James T. Mitchell, Dr. C. N. Peirce, Messrs. Coleman Sellers, Samuel Wagner, Philadelphia (148); Lackawa. Institute of History and Science, Scranton, Pa. (148); Maryland Historical Society, Baltimore (148); Smithsonian Institution (452 packages), U. S. Geological Survey (147, 148, and *Trans.*, xviii, 2), U. S. Naval Observatory, U. S. Patent Office, Surgeon-General's Office,

Coast and Geodetic Survey, U. S. Weather Bureau, Dr. W. J. Hoffman, Rt. Rev. John J. Keane, Prof. Charles A. Schott, Washington, D. C. (148); Prof. E. W. Claypole, Akron, O. (147); Prof. G. W. Hough, Evanston, Ill. (148); Editor of *Kansas University Quarterly*, Lawrence (145, 146, 147); University of Wyoming, Laramie (148); Agricultural Experiment Stations, Raleigh, N. C. (148); Auburn, Ala. (148); Agricultural College, Michigan (145); Observatorio Astronomico de Tacubaya, Mexico (148); Mariano Barcena, Mexico, Mex. (148); Observatorio Meteorologico Central, Xalapa, Mexico (148).

Accessions to the Library were reported from the Royal Society of S. Australia, Adelaide; Académie R. des Sciences, etc., Copenhagen, Denmark; Nederland, Maatschappij bevordering Nijverheid, Amsterdam; Geschichtsvereins, Aachen, Prussia; Naturhist. Verein der Preuss. Rheinlande, etc., Niederrhein. Gesellschaft, Bonn, Prussia; Verein für Schlesische Insektenkunde, Breslau, Prussia; Oberlausitz. Gesellschaft der Wissenschaften, Görlitz, Prussia; Mr. Augustus R. Grote, Hildesheim, Prussia; K. Sächsische Gesellschaft der Wissenschaften, Leipzig; Deutsche Gesellschaft für Anthropologie, etc., Munich, Bavaria; R. Accademia di Scienze, etc., Modena, Italy; Società R. di Napoli, Italia; R. Accademia dei Lincei, Rome, Italy; R. Accademia delle Scienze, R. Osservatorio, Turin, Italy; Université de Lyon, France; Faculté des Sciences, Marseilles, France; Prof. Gabriel de Mortillet, St. Germain-en-Laye, France; R. Statistical Society, British Association for Advancement of Science, Society of Arts, Zoölogical Society, Meteorological Council, Society of Antiquaries, London, Eng.; Royal Geological Society of Cornwall, Penzance, Eng.; Nat. History and Philosophical Society, Belfast, Ireland; Royal Society of Edinburgh, Scotland; Philosophical Society, Glasgow, Scotland; Geological Survey of Canada, Ottawa; Athenæum, Boston, Mass.; Public Library, Salem, Mass.; Amer. Chemical Society, Amer. Museum Nat. History, New York, N. Y.; Central Library, Syracuse, N. Y.; Historical and

Library Association, Yonkers, N.Y.; Amer. Chemical Society, Amer. Academy of Medicine, Easton, Pa.; Penna. Society to Prevent Cruelty to Animals, Girard College, Historical Society of Pennsylvania, Mercantile Library, Penna. Forestry Association, Messrs. Guy Hinsdale, William A. Ingham, Edmund J. James, J. G. Rosengarten, Julius F. Sachse, Philadelphia; Enoch Pratt Free Library, Peabody Institute, Baltimore, Md.; Department of Labor, Washington, D. C.; University of Virginia, Prof. J. W. Mallet, Charlottesville, Va.; Artillery School, Fort Monroe, Va., Elisha Mitchell Scientific Society, Chapel Hill; Mr. Charles Gildehaus, St. Louis, Mo.; Michigan Mining School, Houghton; Agricultural Experiment Stations, Kingston, R. I.; Albany, N. Y.; Geneva, N. Y.; Jacksonville, Fla.; Agricultural College, Miss., Knoxville, Tenn.; Denison University, Granville, O.; Agricultural Experiment Station, Lexington, Ky.; Iowa State Historical Society, Iowa City; Kansas University, Lawrence; Agricultural College, etc., Cheyenne, Wyo.; Colorado Scientific Society, Denver; Agricultural Experiment Stations, Fort Collins, Colo.; Tucson, Ariz.; Asociacion de Ingenieros, etc., Observatorio Meteorológico Central, Instituto Geológico, Mexico, Mex.; Observatorio Astronomico, Quito, Mex.; Sociedad Cientifica Argentina, Buenos Ayres, Argentine Republic, S. A.; Museo de La Plata, Argentine Republic, S. A.

A circular letter from the Naturhistorisch. Vereine der Preussischen Rheinlande, Westfalens und des Regierungsbezirks Osnabrück, Prussia, announced the death of its Secretary, Prof. Dr. Philipp Bertkau.

The Council reported that at the meeting held February 14 the Committee on Premiums had been named, to consist of Messrs. Pepper, Frazer, Ingham, DuBois, Morris, Wistar and Tatham.

Propositions for membership 1332 and 1334 were recommended to be postponed for further information, and 1335 and 1344 were recommended for approval.

It was recommended that the first meetings in February,

May and November be designated for the presentation and free discussion of subjects of broad philosophic interest, and that a Committee of five be appointed to make the necessary preparations therefor.

The recommendations of the Board of Officers and Council were approved and the Chairman referred the appointment of the Committee to the President of the Society.

The following deaths were announced :

Hon. Henry Reed, Philadelphia, February 23, 1896, æt. 49.

Dr. Owen Jones Wister, Philadelphia, February 24, 1896, æt. 70.

The President, by letter, announced that he had appointed J. G. Rosengarten to prepare the obituary of Rev. W. H. Furness, D.D., and that the appointment had been accepted.

The stated business of the meeting being the election of members, the nominations were spoken to, and the ballots cast, Secretaries Frazer and DuBois acting as Tellers.

The following papers were presented for publication in the *Transactions* of the Society :

An essay on "The Development of the Mouth Parts of Certain Insects," by J. B. Smith, Sc.D.

"A New Method of Determining the Perturbations of the Minor Planets," by Wm. McKnight Ritter, M.A."

On motion, referred to Committees for examination and report.

The Tellers being prepared to report, announced that

2278. Dr. A. E. Kennelly, Philadelphia ;

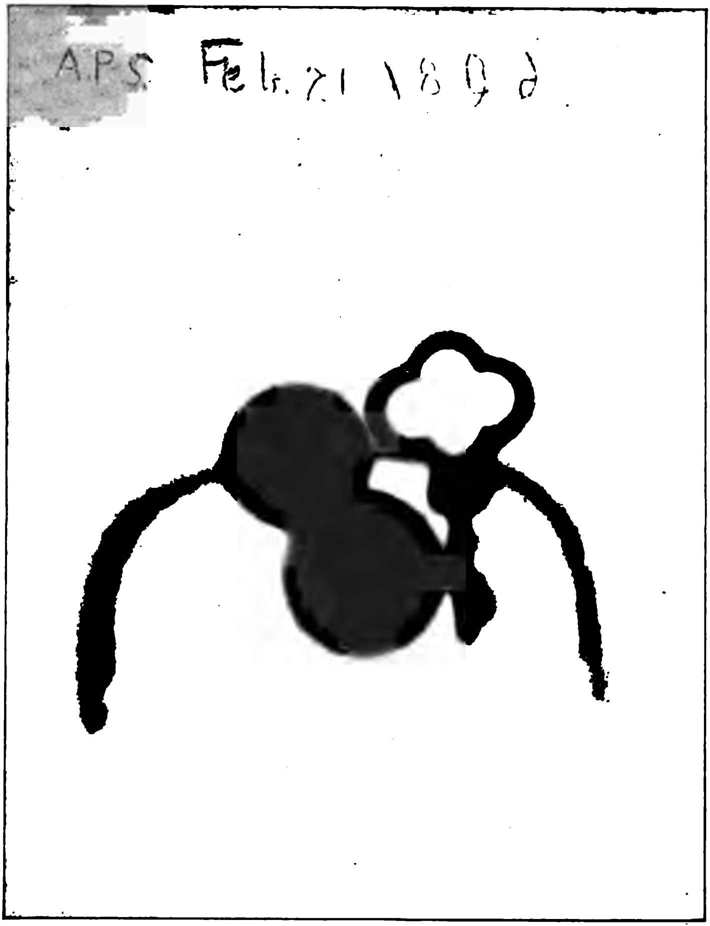
2279. Wm. Pitts Mason, Troy, N. Y.;

2280. Rev. H. C. McCook, Philadelphia ;

2281. Henry Pettit, Overbrook, Pa.;

had been elected.

The Society, on motion, adjourned.



PICTURE TAKEN DURING THE DEMONSTRATION OF THE RÖNTGEN RAYS AT THE MEETING OF THE AMERICAN PHILOSOPHICAL SOCIETY HELD FEBRUARY 7, 1896.

Remarks made at the Demonstration of the Röntgen Ray, at Stated Meeting, February 21, 1896.

Prof. Goodspeed describes his apparatus as follows:

In order to economize time it may be worth while for me to call your attention very briefly to the apparatus that we will use to-night, before beginning the reading of the regular paper. We have here two terminal wires which are supplied with the electric current from several storage batteries which are behind a screen. The electro-motive force is about sixteen volts. This induction coil which is to furnish the current to stimulate the tube has a primary resistance of about three-tenths ohm. The resistance of the secondary coil is about 3200 ohms, dead resistance. By passing the primary current through the small resistance coil and interrupting it frequently, as you all know, we produce an induced current in the high resistance secondary coil. It is the discharge of this induced current through the Crookes tube which you see here that produces the green phosphorescence and secondarily, probably, produces or sets up the form of energy with which we are to deal this evening.

In order to make a test case I will place this little pocketbook, with a couple of coins and an iron key inside it, upon a sensitive photographic plate, which is placed upon the table wrapped in several thicknesses of light-tight paper. The plate, as you will see, is three or four inches below the lower end of the tube. The tube is much larger than is usually seen; and for that reason, probably, is more efficient. The internal pressure is probably about one one-millionth of an atmosphere. The exposure may continue during the reading of the paper. Subsequently we will have the plate developed.

The Röntgen Phenomena.

Gentlemen:—Never before in the history of science has a new discovery commanded such intense and universal interest as that, some of the features of which we have met here to-night to witness. Less than two months ago, the civilized world was startled at the unofficial announcement that Prof. Röntgen, of Würzburg, had discovered a form of energy probably related to radiation, which would pass through many substances that were opaque to known forms of ether energy. An interesting point in this connection was that glass, ordinarily so transparent to light, seemed to be quite opaque to the new energy. Since the original paper of Röntgen has appeared, we have learned that the discovery referred to resulted from a series of experiments on fluorescence. The important pieces of apparatus that were used, and which we have before us this evening, consist of an inductorium with its secondary coil connected to a well-exhausted Crookes tube. A high degree of exhaustion is noted by the absence of a bluish halo about one

or both of the terminals. The internal pressure is about one one-millionth of an atmosphere. The earliest form of vacuum tube, constructed nearly fifty years ago, was exhausted to about one one-hundredth of an atmosphere, and on the passage of an electric discharge, glowed throughout its length with a purplish-blue color. As the efficiency of the pump increased, higher vacuum became easy and the phenomenon of the dark space about the cathode was described and exhibited to the British Association by Crookes in 1879. As the exhaustion is increased the dark space may enlarge so as to extend throughout the length of the tube. Under these conditions, the position of the anode is of little consequence, and under the action of the discharge the whole bulb becomes fluorescent with green or blue according to the kind of glass.

"Cathode rays" is a term applied to the disturbance which seems to start at the cathode within the tube, and extend in straight lines to the opposite side. These rays are capable of being deflected by a magnet, and were supposed by Crookes to consist of the molecules of the residual gas projected with great speed from the cathode terminal and impinging upon the walls of the tube. In the language of molecular kinetics, it may be said, then, that the mean free path of the molecule in one of these highly exhausted tubes, has become greater than the length of the tube. It was discovered in 1890 by Hertz that these cathode rays can pass through some solid substances, *e. g.*, aluminum, while others he found to be opaque. Lenard, the assistant of Hertz, in 1894, passed the cathode rays outside the tube, through a small aluminum window, placed in the wall of the tube opposite the cathode. This window had to be very thin to facilitate the issue of the rays, and yet thick enough, compared with its size, to withstand the pressure of the atmosphere. Consequently, the area was very small. Lenard also obtained shadow records on photographic plates by interposing, between the aluminum window and the plate, opaque bodies.

The cathode rays when impinging upon the Lenard window do not issue in a direction collinear with their former direction; but seem to spread in all directions like a beam of light passing beyond a very small aperture. The transparency of substances for these rays seemed to be closely related to their density. For example, in the case of gases, hydrogen was found to behave like oxygen if it were compressed until its density became equal to that of the oxygen. Transparency to these rays seemed to have no relation to electric conductivity.

With reference to leaving out the aluminum window and replacing it by merely the glass of the tube, Lenard said (*Electrician*, Vol. xxxii, p. 576): "On replacing the aluminum window by one of glass, it was found "possible to repeat all the essential experiments with equal success. But the aluminum remains the more suitable, not that it is the more transparent, but because aluminum is opaque to light, and more easily manipulated than glass of equal thickness." So we see that Lenard actually obtained results in about the same way that we are ex-

perimenting now. Dr. Oliver Lodge, of Liverpool, tried two years ago to repeat this very experiment, with a tube of rather thick glass, "Failing," to use his own words, "simply by reason of insufficient pertinacity." This is doubtless the case, since Lodge has lately repeated Röntgen's experiment with that same tube, obtaining results "through a quarter inch of wood and a sheet of aluminum, provided something like a half an hour's exposure is allowed" (*Electrician*, Vol. xxxvi, p. 438).

Opinions differ as to whether the rays used by Lenard were the same as those producing the Röntgen phenomena. As has been said, cathode rays are deflected by a magnet, while the Röntgen rays seem not to be. The Lenard rays, also, were shown to be capable of deflection by a magnet under certain conditions. Röntgen, himself, is of the opinion that the new energy is some form of ether wave motion perhaps longitudinal, and Lord Kelvin, I think, maintains the same views. Other English authorities seem to be divided between the ultra-violet theory and the longitudinal wave theory.

Dr. Lodge in a lecture before the Liverpool Physical Society, January 27, 1896, expressed himself as rather favoring the opinion that the Röntgen rays are highly electrified material particles, traveling with very great velocity. In a recent article (*Electrician*, Vol. xxxvi, p. 430), Lodge says, that "He permits himself to doubt and inclines to a sort of electrolytic impulsive propagation, through and by means of ordinary matter; in spite of the immensely important fact that Prof. Röntgen can detect in his rays no magnetic deflectibility whatever." In concluding the article referred to, Lodge says, "Meanwhile, the possibility, even the probability, that in these rays we have a new kind of radiation, even though it be only ultra-violet, so high up as to be comparable to the size of molecules, lends to these experiments a prodigious interest in the eyes of physicists, far surpassing the obvious practical applications which have gained the ear of the general public."

Since writing the above, Lodge has himself repeated the magnetic experiment with very great care, finding no deflection (*Electrician*, Vol. xxxvi, p. 471), and expresses himself as follows: "Consequently, the hypothesis of a stream of electrified particles is definitely disproved, as no doubt had already been done in reality by Prof. Röntgen himself."

It seems that Lenard had arrived at the conclusion that he was dealing with two classes of rays, as regards their deflectibility by a magnet. The question may still arise then, May not the Röntgen rays be the undeflectible Lenard rays?

The ultra-violet theory is said to be favored by Professors Schuster and Fitzgerald. One difficulty is, that some electrical conductors are practically transparent to the new radiation. To waves of light of every kind they ought to be opaque according to Maxwell's theory. However, the fact that gold and some other metals, when excessively

thin, are translucent has long presented a difficulty, which is only partially overcome by the assumption, that "the structure is not infinitely fine-grained, with respect to the size of the light waves." It may not be too much to suppose that these new waves are comparable in size with the molecules, or even the atoms, of matter.

The theory of Prof. Röntgen, already referred to, that the new energy is longitudinal ether-wave motion, surely must not be ignored, especially as it seems to be supported, among others, by the distinguished mathematical physicist, Prof. Boltzmann, of Vienna. There are difficulties in supposing the ether to be compressible, yet it must assume the effects of compressibility, if it is to transmit a periodic disturbance with finite speed.

Röntgen's own theory seems well supported by G. Jaumann (Wiedemann's *Annalen*, January, 1896), who has shown in a recent article that by a little change in Maxwell's equations, to satisfy the conditions of high rarefaction, which is met with in a Crookes tube, longitudinal ether waves are possible, which would possess many of the properties of the new rays.

That the new energy does not consist of cathode rays alone, seems to be proved by the remarkable experiment of J. J. Thomson, who placed a protected plate inside the vacuum tube, exposed to the direct cathode stream, and got no result (Lodge, *Electrician*, Vol. xxxvi, p. 473). The same experimenter has suggested an efficient and quick way of detecting the presence of Röntgen rays. An insulated metal plate electrically charged, either positively or negatively, quickly loses its charge when in the presence of the rays. This occurs even when the plate is entirely embedded in the best insulators. It follows, then, that all substances become electrical conductors, when under the influence of the Röntgen discharge.

Should the longitudinal ether-wave theory be demonstrated to be the true one, Prof. Röntgen's discovery would be the greatest of the age, and will open up a vast new field for experimental research, and will likely lead to more definite views concerning the nature of the luminiferous ether.

Soon after the announcement of this wonderful discovery, we began to experiment in the Physical Laboratory of the University of Pennsylvania, at first rather skeptically and quite in the dark as to the exact method of procedure. As the earlier statements implied the necessity of two induction coils, the primary of one connected to the secondary of the other, we were somewhat embarrassed as we did not have two that could be efficiently joined in that way. To show the importance attached to this point by early imitators of Röntgen abroad, let me quote a statement by A. A. C. Swinton, who, I am told, was the first in England to repeat some of Röntgen's experiments. He says (*Nature*, Vol. liii, p. 277), "So far as our own experiments go, it appears that, at any rate, without very long exposures, a sufficiently active excitation of the

Crookes tube is not obtained by direct connection to an ordinary Rhumkorff induction coil, even of a large size. So called 'high frequency currents,' however, appear to give good results, and our own experiments have been made with a tube excited by current, obtained from the secondary circuit of a Tesla oil coil through the primary of which were continually discharged twelve half gallon Leyden jars, charged with an alternating current of about twenty thousand volts pressure, produced by a transformer with a spark gap across its high-pressure terminals."

Having no such apparatus as this at the University, and thinking that possibly some indication might be obtained from a simpler arrangement, we left out the second coil and joined the tube directly to the secondary of the first coil. The coil we are using was constructed by Apps, of London. It has a primary resistance of about 0.3 of an ohm, and a secondary resistance of about 8200 ohms. The Crookes tube which is one of the collection in the physical cabinet at the University, is a shadow tube nearly twenty-five centimeters long and eleven centimeters in diameter at its larger end.

The first result that was unmistakably a success was obtained on Wednesday, February 5. A small slip of glass and a piece of sheet lead, together with a wedge of wood, were held in place upon a sensitive photographic plate by elastic bands, and the whole enclosed light tight in an ordinary plate holder. This was placed horizontally upon a table, eight or ten centimeters below the large end of the Crookes tube. An exposure of twenty minutes produced, upon development, a sharp impression of the objects, the glass and lead appearing opaque, while the portion of the plate covered by the wood was hardly less affected than the parts entirely unprotected. The sight was startling at first as every experimenter who gets the result for the first time can testify. This experiment was immediately followed by an attempt to obtain a skeleton view of the hand, the result of which will be shown by the first slide.

From that time until the present, many experiments of a varied nature have been tried, the object being to investigate substances with reference to their transparency; to detect, if possible, refraction or reflection; to determine the action of various crystals cut in different ways with reference to the optic axis; and a few experiments to test the possible efficiency of a special method of treating the sensitive film.

Early associated with the writer was Dr. H. W. Cattell, who obtained some very curious cases of malformation of the hand and fingers, and produced results which have proved extremely interesting from a surgical point of view.

Our experiments on crystals have not resulted in much that is interesting, except, perhaps, in one case which I will refer to presently. One plate exposed had upon it a tourmaline, a double image prism, a Nicol prism, an amethyst, an irregular quartz crystal, some mica discs,

and some quartz plates with parallel sides. These all seemed to be rather opaque, though I think the exposure was probably too short. We shall experiment in this line at another time.

The second slide shows the skeleton of a lady's hand, which, as far as I know, is the first that has been produced.

The third slide illustrates the difference in the density of the negative caused by times of exposure on the four quarters of the plate of five, ten, twenty, forty-five minutes respectively. During the exposure of each quarter, the rest of the plate was protected by metallic screens. The test objects on the plate, are: a circular piece of cork; a gold coin; a strip of magnesium tape; a piece of glass, and a piece of aluminum. The distance of the tube from the plate was about ten and a half centimeters during all four exposures.

The fourth slide shows the skeleton of a mouse, taken laid flat upon its back; the legs being stretched out and brought as near the plate as possible.

Slide No. 5 shows the density of the negative produced by five-minute exposures, at distances of two and a half centimeters, five centimeters, seven and a half centimeters, ten centimeters and twelve and a half centimeters respectively. The plate was protected by a screen of copper having a circular aperture about one centimeter in diameter.

Slides No. 6 and 7 show the density produced at a distance of two and a half centimeters, with exposures of one to five minutes. These slides were also prepared to demonstrate the efficiency of a plate especially sensitized by Mr. John Carbutt of this city for this work. He conceived the idea that the photographic plate might be rendered more sensitive to this energy, if the film were treated with some fluorescent substance. Mr. Carbutt very kindly placed in our hands some of the special plates, and your attention is directed to a comparison between a very rapid ordinary plate (Seed's No. 27), and the one especially prepared. The treatment throughout was precisely the same. The prepared plate seems to have been considerably more sensitive than the other.

Slides Nos. 8 and 9 show the results of tests to demonstrate the possibility of reflection or refraction, by means of two large diamonds set in a ring. First the diamond ring was enclosed in a flat purse with some coins, and certainly the result is very interesting, though, perhaps, it would be premature to say that anything new is proved by it. The ring was next placed open directly upon the covered plate, and exposed in two positions.

Slide No. 10 shows a possible application of the Röntgen process. Wishing to test the value of the method for detecting flaws in metals, the writer requested one of his associates, Dr. Richards, to have prepared three aluminum plates, four or five millimeters thick, with hidden holes, plugs, or any flaws that might seem desirable. Dr. Richards was asked further to prepare a detailed description of the plates, to sign and seal it, and to bring it with him this evening. The aluminum plates

have been examined by means of the Röntgen process, and it may be interesting if one of your members will open the envelope and compare the description therein, with the one that will now be detailed. The picture tells its own story pretty well, even to the uninitiated. No. 1 seems to have three circular holes, plugged up with some substance, doubtless aluminum, having the same radiographic density as the material of the plate. No. 2 appears to be perfect. No. 3 has two holes similar to those of No. 1, and a third stopped up through a portion of its length by some substance less transparent than the aluminum, perhaps a piece of copper or iron wire (Dr. Richards' Description of Aluminum Plates).

Our experiments during the last two weeks have been made at all times of the day and evening, sometimes in full daylight, and often with no light at all, except that emitted by the tube. The presence or absence of luminous radiation seems not to make the least difference in the results. We early learned that sharper outlines could be obtained by omitting the usual plate holder, and wrapping the plate in several thicknesses of orange paper. By this means actinic light was excluded, and the objects were brought nearer to the sensitive film. During this series of experiments, the writer has received much assistance and many valuable suggestions from his associates in the department, Dr. H. C. Richards, Dr. R. R. Tatnall and Mr. G. C. McKee.

In connection with this subject, it is desired to direct the attention of the gentlemen present to a remarkable coincidence which can hardly fail to excite interest. In the fall of 1889, the writer received a letter from a prominent gentleman in Philadelphia, asking him to call at a convenient and early date, to be presented to a friend who was desirous of obtaining facilities for some experiments in electric spark photography. On the occasion referred to, the writer had the pleasure of meeting Mr. W. N. Jennings, of Philadelphia, who for many years has been much interested in the photography of lightning. It was Mr. Jennings' wish to photograph electric sparks from various forms of apparatus, in order to compare the results with the lightning pictures which he had already obtained. It is needless to say that the series of experiments, begun at that time, have been continued to the present, as occasion and opportunity have made it convenient.

The particular meeting of interest occurred on the evening of February 22, 1890. Slides 11 to 14 show the result of some of our experiments on that evening. We photographed the brush from a large induction machine, by holding the uncovered plate in various positions near the poles. We also placed coins and brass weights on the plates, sparking them by means of the Apps induction coil in various ways. After finishing the experiments of this sort, the writer brought out from the cabinet quite a variety of Crookes tubes, and showed them to Mr. Jennings simply for his pleasure and amusement. The desirability of getting Mr. Ives to reproduce some of the color effects by means of his

beautiful method was suggested. A few days later, Mr. Jennings announced the results of the evening's work and mentioned that several of the plates that had not been exposed directly, but which were developed along with the others, were found to be fogged. He also mentioned one, upon which had appeared a mysterious disc, that he was quite unable to account for as the character of the impression was entirely different from those that had been obtained in the regular way.

The matter was forgotten until about ten days ago, when the writer asked Mr. Jennings to look over the records of our early experiments, to see if we ever exposed a plate entirely covered in the plate-holder. He immediately did so, and found the plate upon which had appeared the mysterious disc. A very reasonable explanation now is suggested. The disc is doubtless the shadow picture of one of the coins made while we were viewing the Crookes tubes. To add still more weight to this theory, we repeated, a few days ago, the experiment in the same way that it must have been made, if at all, on that interesting evening. The original plate and the result of the recent experiment, we have the honor of showing you here. Now, gentlemen, we wish it clearly understood that we claim no credit whatever for what seems to have been a most interesting accident, yet the evidence seems quite convincing that the *first* Röntgen shadow picture was really produced almost exactly six years ago to-night, in the physical lecture room of the University of Pennsylvania.

ARTHUR W. GOODSPEED.

UNIVERSITY OF PENNSYLVANIA, February 21, 1896.

Prof. Edwin J. Houston's Remarks were as follows:

It is unquestionably the fact that although natural truths cry aloud to the scientific inquirer, yet they may long remain unrecognized. We have heard to-night, in the excellent paper Prof. Goodspeed has read, that although the apparatus we have just seen was in the possession of the University of Pennsylvania, and although it undoubtedly long ago produced the Röntgen effects, yet they were undetected. I had myself a similar apparatus in the philosophical cabinet of the Central High School; and the Röntgen rays were unquestionably produced by it, but they were not recognized. Many a case of a curious shadow photograph, appearing mysteriously upon a plate believed to be good, strange shadows coming out, the cause of which could not be detected, were most probably some of these Röntgen photographs.

The paper we have heard has reviewed in so able a manner the comparatively few facts that are known concerning this peculiar form of radiant energy, that I may, in my remarks, be forced to repeat some of its statements, but it may, nevertheless, be of interest to you if I do so in other language.

The term cathode rays is applied to the stream of electrified molecules

that pass in a rectilinear direction from the negative electrode, or cathode, of a suitably exhausted vacuum tube. This peculiar effect is not observed to any marked degree until the residual atmosphere in the tube has a tension or pressure of but about the one-millionth of an atmosphere, or until that peculiar condition of matter in the tube is obtained, for which Crookes proposed the name of the ultra-gaseous, or radiant state. It appears that wherever the cathode rays strike the walls of the tube, or any suitable substance contained therein, they excite fluorescence. The cathode rays are deflected by magnetic flux. Indeed, they must be so deflected if they consist of streams of electrified molecules; for, their deflection by magnetic flux is a phenomenon allied to the deflection of a voltaic arc by a magnet, or the deflection of the active wires on an electromagnetic motor, by the flux from the field magnets.

Reviewing briefly the history of the Röntgen discovery, we will find some of the facts to be as follows; viz., Hertz showed that thin metallic films are transparent to the cathode rays. Lenard, an assistant of Hertz, who afterwards took up the investigation both in connection with Hertz and individually, placed an aluminum window in the tube so that the cathode rays impinged on it. You probably noticed, in looking at the radiation from the tube shown by Prof. Goodspeed, that the rays did not light up the entire surface of the tube, but that a spot directly opposite the cathode was markedly excited by the phosphorescence. That is the spot where a peculiar kind of radiation, called the Lenard rays, or the Röntgen rays, was observed; the Lenard rays in one condition of the vacuum, and the Röntgen rays in another condition of the vacuum. Assuming, that the cause of the Lenard or Röntgen rays is the impact of a molecular stream of electrified particles, most probably molecules, we may inquire as to their origin. They are evidently either disengaged from the substance of the negative electrode or cathode, or they are simply the molecules of residual gas in the highly exhausted tube. Inasmuch as Pupin has shown that electrodeless Crookes tubes, that is, tubes not provided with interior electrodes, produce the same effect, it would seem fair to believe that botht he Lenard and the Röntgen effects may be due to molecular bombardment of the molecules of the residual atmosphere. In these electrodeless tubes, pieces of tinfoil are placed on the outside of the tube, and the terminals of the Ruhmkorff coil being attached to them, discharges are produced by electrostatic induction corresponding to the discharges of the secondary of the Ruhmkorff coil, and all the effects of either the Lenard or the Röntgen rays are produced.

Lenard states that his rays are faintly visible to the eye outside the tube. They are, however, rapidly absorbed by the air, so that at a short distance from the tube they cease to be visible. The Röntgen rays, on the contrary, are invisible to the eye. Both the Lenard and the Röntgen rays produce phosphorescence in phosphorescent materials

on which they impinge; they both traverse opaque films of metal; they both produce actinic effects on photographic plates. That the Röntgen rays are something different from the Lenard rays is proved, I think, by the fact that they are not by any means so absorbable by air.

It may be interesting to know how Röntgen's original effects were obtained. He took an ordinary Crookes tube, or at least a tube containing the proper vacuum, and completely covered it with blackened pasteboard so as to render it light tight to ordinary light. He took a paper screen which he painted with a substance capable of being excited by fluorescence, a solution of barium-platino-cyanide. He then found that wherever this screen was impinged on by the Röntgen rays, it fluoresced.

Röntgen found, that his rays, like the Lenard rays, possess the strange power of passing through many substances opaque to ordinary light. It is generally believed that the source of the Röntgen rays is the portion of the glass tube which receives the bombardment of the molecules shot off from the negative electrode. In other words, the Röntgen rays are caused by the cathode rays. That they are not the cathode rays themselves is evident from a brief review of some of their characteristics.

1. The Röntgen rays are invisible to the eye.

2. They excite fluorescence. (In this respect, however, they agree with the cathode rays and the Lenard rays.)

3. They produce actinic effects. In this respect they agree with the Lenard rays, but are entirely differentiated from the cathode rays. A photographic plate has been placed inside a Crookes tube and the cathode rays have been caused to impinge on it. They failed to produce any actinic effects. There are clearly then these differences; the Röntgen rays produce actinic effects; *i. e.*, they possess the power of decomposing a photographic salt placed on a sensitive plate, and are not deflected by a magnet. This latter point has been confirmed recently by some very careful experiments made by Dr. Oliver Lodge. The apparatus would have detected any deflection had it existed.

There is, however, a marked similarity between the Lenard and the Röntgen rays. The source of both is believed to be the cathode rays. They each produce fluorescence; each possess the power of passing through substances ordinarily opaque, the opacity increasing apparently with the density, though not in direct proportion with the density. The Röntgen rays, however, differ in the valuable property of not being so readily absorbed. The Lenard rays, though not deflected by a magnet, in free air, are deflected by a magnet when they are caused to enter a highly exhausted chamber—at least, so Lenard states. It is said that Prof. Wright, of Yale, a careful student and one whose opinion is to be regarded, does not think that the Röntgen rays differ from the cathode rays. He rather looks on the Röntgen rays as strained cathode rays.

That the Röntgen rays possess three characteristics of ordinary light; viz., rectilinear propagation, as shown by their ability to cast shadows; the power of producing fluorescence; and the power of effecting chemical decomposition in a sensitive photographic plate. They differ from light, however, in nearly all other respects. If they are ether waves they may be transverse waves, which we know of; or they may be the long-looked-for longitudinal waves. They are, however, apparently incapable of reflection, refraction or interference, all characteristic of transverse vibrations. If they are transverse vibrations they belong to some part of the spectrum that we have not hitherto studied. In the opinion of some physicists they belong to a region considerably below the red; in the opinion of others they are exceedingly short wave lengths, possibly approaching atomic or molecular dimensions.

I have used in connection with my colleague, Dr. Kennelly, in the study of the Röntgen effect, both the character of apparatus described by Prof. Goodspeed, as well as other apparatus. Dr. Kennelly and I, charge a battery of Leyden jars with the discharge of a large Ruhmkorff coil; we get a spark discharge and a spark gap, and then use that spark discharge, which is an oscillatory discharge, through the primary of a Tesla coil. We thus obtain in the secondary coil an exceedingly high discharge and use this to excite the Crookes tubes. The Tesla coil was immersed in rosin oil. It seems from the experiments we have made that these very rapid oscillations are not so apt to injure the tube and apparently produce better results. However, in sharp opposition to this, I hear a rumor, though it is only a rumor, that at the Johns Hopkins University they are working in the opposite direction; viz., with very few oscillations of the primary per second. I hope Prof. Rowland, who is conducting these experiments, will soon let us know what he is doing.

Mr. Edison has been a tireless investigator in this field of physical research.

Prof. Schuster is decided in his opinion that the Röntgen rays are not the cathode rays. He agrees that the point of origin is where the stream of negatively charged molecules strikes the glass. Prof. Whiting finds gum to be the most transparent and rock salt the most opaque substance to the action of the rays. Prof. J. J. Thompson states that the cathode rays are incapable of affecting sensitive photographic plates. We all know that the ultra-violet rays, which some think are the same as the Röntgen rays, will effect the discharge of a negatively excited body. Prof. J. J. Thompson has shown that the Röntgen rays will effect the discharge of either a negatively or a positively excited body, and this whether or not the body is surrounded by the highest insulating substances known to the electrician, like vulcanite or parafine. Of course, I know that most of you will know what this means; viz., that a leak takes place in those substances; or, in other words, that while the Röntgen rays are passing through these substances they become conductors of electricity.

Mr. Carbutt: Do I understand you to say that no positive results have been obtained yet at the bell of the receiver of the exhaust pumps?

A. I say that I understand that no sensitive plate has yet been obtained, which, placed in the Crookes tube, will have any actinic effect produced on it by the cathode rays. When they pass outside the tube they are no longer cathode rays.

Q. But if placed on the bell of the receiver of an exhaust pump?

A. I have not tried that.

Q. Just to-day I made the experiment of exposing a pair of steel scissors; and in five minutes obtained a strong negative effect, getting my rays from the negative pole.

Q. Then they went through the glass of your receiver?

A. No, sir; they struck right on the metal scissors.

Q. Where had you your photographic plate?

A. On a bell receiver. I used no Crookes tube, nothing but just the rays as they came down from the negative pole. The plate was lying on a little table as connected with the positive pole and the rays were seen traveling down on the plate on which were laid the scissors.

A. I think you had an effect very much like the electric discharge effects shown on the screen to-night. I believe that a great many statements made concerning the ability of other sources of light to produce Röntgen rays are due either to heat effects, or to electric effects.

Dr. J. Cheston Morris asked if Edison was experimenting with celluloid plates. Prof. Houston said he did not know.

Remarks by Mr. Julius F. Sachse were as follows:

So far as the photographic properties of the new X rays of Röntgen are concerned, it is yet a question whether they will ever be of any practical value or use for photographic purposes, as the term is usually understood.

The fact that these rays can neither be refracted, condensed nor dispersed, is a fatal objection to their application to photography.

It will be noticed that all of the registered or permanent results obtained and shown here this evening are by no means photographs in the ordinary sense of the word; they are merely fixed shadows or "sciographs" obtained by the interposition of a sensitive gelatine plate.

I do not wish to be understood as depreciating this new factor in physics, nor to appear skeptical as to any practical results that may be forthcoming in the future. It is now certain that a great discovery has been made by Prof. Röntgen, notwithstanding the fact that these identical rays have been produced thousands of times, in nearly every physical laboratory in the world, and that it only needed the neighborhood of a luminous film to reveal them, and to do this was Prof. Röntgen's opportunity. The step to substitute a sensitive plate to register the shadow was a short one, and we have here to-night a practical demonstration of the results.

I now wish to call your attention to another peculiarity of the new Röntgen rays, that has just come to my notice, and had time permitted, I should have had the specimens here to illustrate my remarks.

The most exhaustive series of photographic experiments thus far made in connection with the Röntgen rays are the investigations at the Imperial experimental institution at Vienna (K. K. Lehr- und Versuchsanstalt für Photographie in Wien). Thus far no results have been obtained greater than the original skeleton hand of Prof. Röntgen. Scientifically, however, the curious fact has been learned that the actinic action of the so-called X rays is dependent to a great extent upon the medium or support that holds the haloid salts in suspension.

It appears that for some reason as yet unknown the new Röntgen rays have a peculiar affinity for a sensitive plate whose support consists of animal matter or gelatine. Now if we take a plate of equal sensitiveness, but substitute collodion for gelatine, and expose it to the action of the X rays, no effect whatever is produced. The rays seem to be absolutely inert the moment any medium is substituted for the animal support of the ordinary commercial dry-plate.

This series of experiments at Vienna consisted in testing the ordinary bromo-argentic gelatine dry plates of different degrees of sensitiveness together with argentic-iodide collodion (wet) plates—bromide collodion emulsion, and moist eosine bromo-collodion (Albert emulsion) and argentic chloro-bromide collodion plates, the latter developed with an alkaline solution.

The result of this series of experiments was that the Röntgen rays made little or no impression upon any variety of the collodion plates whether wet or dry, while upon the contrary every variety of gelatine plate, no matter whether sensitized with argentic bromide, iodide or chloride, proved a ready recorder for the Röntgen rays. The most effective plates were what are known in Germany as the "Schleusner Rapid" bromo-gelatine dry plate; they are equal in rapidity to our American plates "Sensomiter 23."

It appears from this series of experiments that the most marked difference was found in the comparison of a chloro-bromo-gelatine dry plate with a collodion wet plate, both of which were carefully tested as to their equal sensitiveness by daylight prior to being exposed to the effect of the X rays. Where the dry plate with alkaline development proved a success, the wet plate with an acid-iron development was an absolute failure.

Another peculiarity shown was that an alkaline development in every case gave better results than a neutral or acid one. Then again when a dry plate of the kind giving the best results was moistened or dampened before exposure, the sensitiveness for the X rays was greatly diminished.

Here perhaps we may find a solution to the problem why it is that none of the American results obtained by use of the X rays thus far have been equal, either in distinctness of outline or reproduction of detail, to the German sciographs. It may be to the humidity of our atmosphere, more

than to the quality and character of our photographic dry plates, or the lack of skill of our experimenters, that we have to look for either cause or failure.

It will thus be seen that many new factors enter into the photographic development of the new forces. Conditions seem to arise at every turn that are entirely foreign to those encountered when we work with either solar or artificial light, and this independent from the optical features which I have mentioned.

Now the question naturally presents itself as to which kind of sensitive plate, or medium, should be used to obtain the maximum results of the actinic action of the X rays, or in other words, by what means can we obtain the best permanent Photo-Sciographs?

As to the difference between the action of the X rays upon gelatine and collodion I would venture the theory that if these results are confirmed by experiments here, that it is due to the fact that while gelatine arrests the X rays, they pass through or penetrate the collodion film. If this should prove to be the case, it would indicate the use of double-coated plates, or of a stripping film upon a support impervious to the X rays, such as a sheet of lead. By such means perhaps photographic results of still greater value might be obtained. I will here state incidentally that the Schleusner plate used in the German experiments is coated somewhat heavier than the average American plate.

I now come to another aspect of the possible development of the photographic properties of the new forces; an experiment thus far untried in connection with the Röntgen rays. For this purpose I will turn backward and take recourse to the original principles of heliography, and suggest a series of experiments wherein we substitute for the gelatine dry plate a highly polished sheet of metal, subjecting it to the action of the X rays in the usual manner, and then seeking to develop the impinged image, if there be one, with the fumes or vapor of mercury or iodine, or the two in combination, a process well known to photo experts of the old school.

Tests should also be made upon the silvered copper plate coated with the vapor of iodine and bromine and developed with the fumes of mercury (the old daguerreotype process); or upon plain sheets of polished copper, silver or tin, and developed either with vapor, or by the application of heat to the reverse side of the plate; a process known as "Hunt's Thermography."

The above experiments are well worthy of a trial in connection with the development of what may be called "photo-sciography."

In conclusion I will call your attention to a curious coincidence. It was in this room just fifty-three years ago during the centennial celebration of this Society (May 29, 1843) than an almost identical topic formed the theme for discussion, viz.: Moser's theory of "Invisible photographic rays," a theory which was then attracting great attention in scientific circles on both sides of the Atlantic. Remarks upon the subject were

made by a number of members present, among whom may be named Dr. Paul Beck Goddard, Joseph Saxton, Prof. Henry and Prof. James Rodgers, all names that are still held in high esteem in the scientific world.

While upon the subject of Moser's theory, I will state that there have of late come to my notice several cases which seem to confirm his theory of latent light, or invisible photographic rays. The most marked instance was where a number of platinum prints were packed away and laid undisturbed in the dark for several months, and in several cases had reproduced themselves or formed a reverse positive picture upon the surface of the white plate paper mount which laid immediately over the print I merely mention this matter at this time so as to place it upon record, as I expect to bring it before the Society in a more formal way in the near future. As a fitting close to this paper I will quote the language of Robert Hunt, used in connection with Moser's theory and read here half a century ago, as it will apply with equal force to the theory of the unknown waves known as the X rays of Röntgen: "As a subject of pure scientific interest this discovery promises to develop some of those secret influences which operate in the mysterious arrangements of the atomic constituents of matter, to show us the road into the hidden recesses of nature's works, and enable us to pierce the mists which at present envelope some of its most striking phenomena. It has placed us at the entrance of a great river flowing into a mighty sea, which mirrors in its glowing waters some of the most brilliant stars which beam through the atmosphere of truth."

Referring to the paper read by Mr. Julius F. Sachse, Mr. Joseph Wharton asked:

Q. Will the gentleman please explain more fully what is the action of the X rays upon the more sensitive gelatine film as contrasted with their action upon the collodion?

A. I have not had the time to verify it by experiment; but as the case stands at present I cannot explain it except that the rays pass through the collodion film: they fail to arrest. That is the only explanation I can give at the present moment.

Q. That seems to be somewhat at variance with many of the observations that we have had set before us to-night: namely, that a number of so-called colloid bodies seem to be pervious to the ray; while a number of the crystalloid bodies seem to be impervious. Here are pitch, gum, leather and several other bodies which are pervious to the ray (all colloids); while quartz, rock salt and other crystals (the speaker naming several) all appear opaque to the ray. It may be worth while to bear in mind, in future investigations, the question whether there may be a line drawn between colloids and crystalloids in transparency for the new ray, and if so to search for the reason of that distinction.

Remarks of Prof. Robb, of Trinity College, Hartford:

We are all indebted to Prof. Goodspeed for a very interesting paper and must congratulate him. There is certainly a great deal of interest in those slides. The first thing that attracted our attention in Hartford about our dry plates was the fact that on a great many of them we noticed second images which were clearly defined, but fainter than the first, having decidedly the appearance of the ordinary halo images of ordinary photography. At first glance one might think that was due to reflection. I am sure it was not due to any movement that occurred in the plate ; and I am sure it was not due to a violet region of photograph. I think exposures in bright light are a very dangerous thing. It is very possible to get shadow photographs through any of the commercial plate colors ; but in a great deal of our work where we have worked in the ordinary light we haye taken the precaution of using an aluminum cover of over a thirty-second of an inch ; and we get second images to the same extent using the aluminum cover. Of course there are various explanations of it. It might be from fluorescence or other things that may suggest themselves to you.

With reference to Prof. Moser's slow plates giving better effects than rapid plates, that has not been our experience. We gave up the most rapid plate. We experimented with the most rapid plate that we could get, and we found some twenty of the plates were apparently light-struck ; and finally we settled the question they were not light-struck ; they were electric-struck by the brush discharge at the lower end of our Crookes tube.

One thing is very apparent to all of us that have been doing much work in this line—that the induction coil needs improvement. For as at present constructed they are not made to run continuously for twelve hours. They are all right to run for a few moments for showing off Crookes tubes ; but platinum terminals soon wear out or become hot ; and we have to put on new ones. In that connection I have a very good idea, due to a mechanic who does a great deal of work for me, which I will show by a sketch. The platinum point is about a quarter of an inch long ordinarily and is attached to the end of a tube having a thread on it and gradually wears away. Instead of fastening that piece of platinum directly under the tube we take a piece of platinum wire four or five inches long and place it on the end of a second metal rod which screws into the first. In that way, instead of having simply a quarter of an inch of platinum to wear off, we have some four or five inches at our disposal ; and in the next place the heat is dissipated long before it gets to the soldered joint.

I think in connection with these photographs, there are shadow photographs ; but it is remarkable what an amount of detail we can see on some of it. I have a photograph of a razor taken inside of the case which is interesting to see. When we looked at it, it was very bright in the middle of the razor—more light coming through there than at the edge.

One of my students said it must be a hollow-ground razor; and so we found it upon measurement. The photograph that we saw on the screen by Prof. Goodspeed of the aluminum plates with various holes bored in them was interesting, both as showing what can be done in the case of aluminum and what may be done in the case of other metals. From anything we know now as to the Röntgen rays, it will be impossible to tell much about armor-plating or anything of the kind; or about the molecular construction of any considerably thick pieces of the more opaque metals; but it does seem as though we can discover forms of ether vibration that will go through aluminum and go through hard rubber, and other forms that will go through pitch and things of that kind, and that certainly some day we are going to discover some form of ether vibration to which iron may be transparent. Of course we can all see what a tremendous application that would have in the mechanic arts.

We have one or two rather interesting photographs from a medical standpoint, showing its possibilities. Two or three of the students in photographing their hands discovered differences. One case of sesamoidal bone is very apparent, between the thumb and fore-finger of one of the students' hands; and then just two or three days ago we had a laboring man who was out of work from an injured hand; had been injured in a runaway accident and had gone to a local physician who has quite a reputation for doing poor work; had his hand treated; and it was never getting well; and we put it under the Crookes tube and, sure enough, there was a partial dislocation and a fracture which had never been attended to properly. Of course he was very glad to have us point out how to remedy it.

We have experimented slightly with a very interesting Crookes tube. We made a Crookes tube out of an ordinary lemonade shaker—whisky shaker—I don't know what you call it down here—with a hard rubber end in it; and the results have been very negative. We have never gotten any shadow photographs with it. We have simply taken three or four photographs with it.

Mr. John Carbutt's remarks were as follows:

My interest in the new Röntgen rays has been from the first reading of them. Being so interested in photography, when reading of the wonderful results produced by Prof. Röntgen, I naturally saw that there was going to be a much larger outlet for dry-plates. Outside of its commercial value I naturally took an interest in its scientific aspect; and the first thing that struck me was the great length of time for which the objects had to be exposed to the Röntgen rays. I therefore made it my business to investigate and to see whether or not a plate could not be produced which should be more sensitive to the Röntgen rays; and, as mentioned by Prof. Goodspeed, I experimented with the fluorescent substances, having experimented with numerous dies in the making of anthochromatic

plates. I knew that several of them gave off a great deal of fluorescence. I have only produced plates printed on glass; but I shall take up a line of experiments at once by producing some on thin celluloid; because, for the physician and others that have cases to tend where the flat plate would be very difficult to use, the celluloid can be enclosed in an envelope —sufficiently opaque to ordinary light—and can be bound around the elbow or the shoulder or any part sufficiently round where a plate would have to lie flat; and I think it would find in that case several uses. I have been experimenting with some professors (which matter I am not at liberty just now to mention) when I made a sciograph negative of a woman's hand in twenty minutes, plates as large as 14 x 17 being used. A film of the same size could be bound around the back, for instance; and I think in that way that possibly the celluloid film (it is $\frac{10}{100}$-ths thick) may possibly come in use. As it has been mentioned that Mr. Edison has been using slow to quick plates, I have not as yet experimented with anything slower than a very rapid plate and am inclined to increase its sensibility; and I think that in a measure I have succeeded, as Prof. Goodspeed has shown you. Since the sensibility of these rays is a subject that requires both study and experiment, I do not propose at the present moment to say that I fully understand all of its requirements; and it is in its experimental stage. I shall not let the matter drop; I find it very difficult to find any tubes that are giving the proper X rays. The one that Prof. Goodspeed is using, so far as I have seen, is the best one that I have come across. I have been using one to-day with which I gave a full half-hour's exposure and got no results. The reason was explained to me to-night in the remarks that were made that when a blue or a purple color comes from the negative or cathode end of the Crookes tube it is not efficient in giving off the X rays. There is no doubt that a great many professors who are trying these experiments and getting negative results are working with inefficient Crookes tubes.

Remarks of Dr. William Pepper were as follows:

I rise only to occupy the attention of the Society for a single moment. In pursuance of the suggestion of Dr. Minis Hays to me, we owe very much of the pleasure of this evening's discussion, he having suggested that I write to some friends in Canada; and as a result of it, I present from Prof. Cox, of the MacDonald Physics Building at McGill University, Montreal, this brief note, accompanied by these four very excellent photographs illustrating the application of this method to surgical diagnosis.

"THE MACDONALD PHYSICS BUILDING,
"MCGILL UNIVERSITY,
"MONTREAL, February 18, 1896.

"*Dear Sir*:—Dr. Shepherd has sent to me your letter expressing a wish to have some of our photographs for the meeting of the American Philosophical Society on the 21st.

"Our results have been in no way peculiar except that we were fortunate in making a successful application to surgery almost at the start. I have nothing to describe in the way of new methods. In fact there seems at this moment to be nothing known or tried that was not suggested in Röntgen's original paper.

"I am forwarding as likely to be of most interest a proof of the negative showing the revolver bullet between the tibia and fibula of a man's leg. This was obtained on February 7, four days after my first photograph. The print shows a copper wire fastened around the leg above as a fiducial mark;" (here Dr. Pepper interpolated as follows to the closing of this parenthesis: "then on the Röntgen sciograph should be seen between the tibia and fibula both in the positive and negative the small darker shaded area indicating the position of the bullet") "and the flattened bullet between the bones. The latter was extracted next day; and the patient is now nearly well enough to leave the hospital. The bullet was two inches deep in the flesh and had been flattened into a ragged-edged disc with a groove where it was lying against the bone. It had been in the leg since Christmas night. Its position was guessed at; but the photograph converted a surmise into a certainty. On the same night, February 7, we obtained the hand of which I send a copy. It was interesting not only for its good definition (for a fourth attempt), but because it shows the rare sesamoid bones on the thumb and little finger. It belongs to a champion canoeist.

"The main ideas I have found time to try—increasing the sensitiveness of the plate by (1) placing a fluorescing screen inside the holder in contact with it: (2) soaking the plate in the fluorescing substances—I now see have been successfully carried out by Geissler, of Bonn; so that I have nothing new to interest your Society.

"Believe me,

"Very truly yours,

"JOHN COX."

"The idea was to excite sympathetic fluorescence and gain intensity by resonance."

Dr. Pepper, continuing with original remarks:—As to Mr. Carbutt's remark as to obtaining flexible discs for curved surfaces and this (from Prof. Cox) interesting contribution as regards the diagnosing of internal conditions, I would say the excitement has spread the world over; every day I am receiving numerous letters, telegrams, visits from people at a distance, coming to ask whether it has yet reached a point to become an aid to internal diagnosis. I will not at this late hour occupy the attention of the Society by calling their thoughts to the obvious, the very great difficulties of this method. The tissues which are inaccessible to the hand in palpation are guarded so often by bony surfaces that the danger of shadows existing—which will be almost more confusing than the difficulties which surround our present means of diagnosis

—is very obvious. The field of investigation is of enormous proportions. The assistance of Prof. Houston and his associate, Dr. Kennelly, is promised in entering on an elaborate series of investigations in this direction. Whatever may be the result, we promise ourselves the pleasure of submitting them at a later period to the attention of the Society.

I have also here a few photographs of Dr. Henry Cattell; but as most of them have been published before I do not know whether he would care to show them at present.

Mr. Wharton exhibited a tube containing argon produced by Lord Rayleigh, which was presented by him to Dr. Theodore Wm. Richards, of Harvard University. This tube being arranged for sparking was introduced into the current of a Ruhmkorff coil, where it made a fine display of color.

A number of the members examined this with a spectroscope provided by Dr. Goodspeed, and thus observed very clearly the characteristic lines of argon.

Stated Meeting, March 6, 1896.

President, Mr. FRALEY, in the Chair.

Present, 24 members.

Mr. Henry Pettit, a newly elected member, was presented and took his seat.

Correspondence was submitted as follows:

Letters accepting membership from Dr. A. E. Kennelly, Philadelphia; Prof. William Pitts Mason, Troy, N. Y.; Dr. Henry C. McCook, Philadelphia; Mr. Henry Pettit, Overbrook, Philadelphia.

Letters of acknowledgment from Prof. A. E. Nordenskiold, Ph.D., Stockholm, Sweden (143, 146); R. Accademia di Scienze, etc., Modena, Italy (143, 144, 145, 146); Buffalo Library, Buffalo, N. Y. (148); Dr. Albert P. Brubaker, Philadelphia (147, 148); Hon. J. D. Cox, Cincinnati, O. (148); Colorado Scientific Society, Denver (148); Bishop Crescencio Carrillo, Merida, Yucatan (148).

Accessions to the Library were reported from the Linnean Society of N. S. Wales, Sydney; Société Hollandaise des Sci-

ences, Haarlem, Holland; K. D. Geographische Selskab, Copenhagen; Société R. de Géographie d'Anvers, Belgique; Gesellschaft für Erdkunde, Berlin, Prussia; K. Gesellschaft der Wissenschaften, Göttingen, Prussia; Società R. di Napoli, Italia; Dr. E. T. Hamy, Paris, France; Philosophical Society, Cambridge, Eng.; Theological Seminary, Andover, Mass.; Academy of Natural Sciences, Indian Rights' Association, Prof. William F. Norris, Philadelphia; U. S. Naval Institute, Annapolis, Md.; Agricultural Experiment Stations, Atlanta, Ga.; Las Cruces, N. M.; Historical Society, Los Angeles, Cal.; Observatorio Central, Xalapa, Mexico; M. Alberto Sanchez, San Salvador, C. A.

A crayon portrait (framed) of Hon. Eli K. Price was presented to the Society by J. Sergeant Price, Esq.

The committees appointed to examine the papers, "A New Method of Determining the Perturbations of the Minor Planets," by Wm. McK. Ritter, M.A., and "On the Development of the Mouth Parts of Certain Insects," by John B. Smith, reported in favor of their acceptance, and on motion they were referred to the Publication Committee for action.

Dr. Frazer then read a paper by Dr. Edw. Pepper, entitled "Eucalyptus in Algeria and Tunisia from an Hygienic and Climatological Point of View."

The subject was further discussed by Prof. Houston, Dr. Brinton, Dr. Wm. Pepper, Dr. Frazer, Prof. Cope and Dr. Morris.

Dr. Morris, on behalf of the Curators, acknowledged the receipt of the shadow picture, and the photograph from it, taken by Prof. Goodspeed during his demonstration on Feb. 21, and by permission of the Society was allowed to present his views on the subject.

It seems to me that such pictures should be called, not skiagraphs, or photographs, but electrographs; as they may be produced under various circumstances involving absence of light, but always the presence of some form of electrical energy—such as frictional electricity from the driving belt of a wheel, or a magnet (as has been done in Baltimore), or the direct rays of the sun in the presence of substances opaque to light and heat.

It seems also to me that we have evidence, apparently convincing to our senses, of a current or flow of a stream of some sort through the

Crookes tube, *e. g.*, the rapid rotation of the radiometer when exposed to it. This current or stream, of whatever it may be composed, is striking with great intensity and velocity more than four hundred million times per second against a thin film of glass which is not in a normal condition of equal pressure on both sides—on one side is a vacuum more or less perfect, on the other the whole pressure of the atmosphere. Such rapid blows cannot do otherwise than place the glass in an electrically excited condition—precisely like that of the plate of an ordinary electrical machine. As the exciting cause in this case is a current of negatively electrified molecules of air, the inner surface would be negative, and the outer intensely positive, and this would induce corresponding conditions in all neighboring bodies. The current might be very small, but of very high potentiality; hence would penetrate deeply these surrounding bodies, but would also produce in them all the phenomena of induction. To this excited condition of the glass film of the Crookes tube we may refer the phenomena of phosphorescence, fluorescence and heating, which ensue by the transmutation of forces—just as when a stone is thrown into a pond waves of various size and frequency will be seen to be propagated and interfere with each other. That induction is the cause of the formation of the picture is rendered probable by the fact that the reduction of the silver salt takes place next to the glass of the photographic plate, and not on the free or gelatin surface; and I would suggest as worthy of experiment whether the same effect would not be produced through a series of similar plates and not only on the uppermost one. Prof. McFarlan, of Easton, has shown beautiful results proving the radiation of the energy from the cathode of the tube, which also accord with the induction hypothesis. With regard to the useful applications of these rays, they seem to me to afford a rational explanation of some of the benefits of the currents of induced electricity on nutrition and other vital functions, which those of us who have employed it in our medical practice have often observed without being able fully to explain, and which we can therefore use more intelligently and beneficially hereafter. So also with the effects of the direct sun-rays, or sun-bath, known from ancient times.

The plate shows the edge of the coins and other metallic bodies not clearly defined, but surrounded as if with a shadow, or shading off; this, when examined closely, seems to be composed of fine lines radiating from the coin or metal.

I therefore believe that the phenomena in question will be found to be due to an induction of statical electricity, in great measure if not entirely.

It may be well also to call attention to the fact that while sound, heat and light can be reflected, refracted, transmitted or absorbed, no similar phenomena have as yet been shown as to electric, galvanic or magnetic forces.

New nomination for membership 1346 was read.

The President announced that he had appointed Dr. Pepper, Dr. Frazer, Mr. Ingham, Mr. Jos. C. Fraley and Dr. Hays the Committee for the special meetings agreed upon at the last meeting of the Society.

The Society was adjourned by the President.

Eucalyptus in Algeria and Tunisia, from an hygienic and climatological point of view.

By Dr. Edward Pepper.

(Read before the American Philosophical Society, March 6, 1896.)

INDEX.

I.

Division of Algeria and Tunisia into Three Zones as Regards Climate, Water, Trees, Health and Population.

Division of Algeria and Tunisia into three zones as above indicated.

Algeria and Tunisia are properly divided into three zones as regards climatological, hydrological and botanical, as well as hygienic and ethnographic conditions.*

The southern zone, The Sahara, consisting generally of a vast area of sand, moving and yet in parts solidified as by petrifaction (hamada), inhabited by semi-barbarous and roving tribes; and of oases of date-palms, inhabited by settled and less barbarous communities.

The middle zone comprises the high plateaux, or steppes, covered with a wild vegetation (herbaceous, fructiferous and rarely arborescent)

* As regards purely hydrographical conditions, these countries are divided into only two zones: the basin of the Mediterranean and that of the desert, all water not flowing in the one flowing in the other direction. But as regards practical hydrology or hydroscopy and its influence on the climate, these colonies are, as stated, properly divided into three zones here described.

and sustaining numerous flocks of sheep and camels; also sparsely inhabited.

Finally the northern zone, or coast region, El Tell, is generally cultivated and much better watered and wooded, and has both plains and valleys, hills and mountains. Here the European population of three or four hundred thousand only slowly increases by birth as well as by immigration, among three or four million more prolific lowland Arabs and Kabyle mountaineers.

The year has but two seasons.

The Algerian and Tunisian year has but two seasons: the dry and the wet. The former or summer comprising three rainless months, July–October, and the latter or winter months, October–March, offering generally short and frequently heavy showers and rains, and four months of showers lighter and fewer as the season draws to its close. The transition between these seasons is often sudden, an almost vertical sun radiating great heat over the land as soon as the cloud-screens have disappeared from the atmosphere.

Local climates abound in the coast region.

A peculiarity of the coast region (the Tell) is the diversity of the local climates (in most cases improperly called artificial) due to geological and geographical conditions, such as the nature, conformation and lay of the land as regards the higher hills and mountains, valleys and rivers, the sea, lakes, etc.; and also to orographical characteristics, such as the height of the mountains, the depth of these valleys, etc.; as well as to hydrological facts, such as the presence, absence, abundance or scarcity of the waters, flowing or stagnant, either above or underground. These local climates also depend on the extent of the surface cultivated, and, to a lesser degree, on the nature of the plants grown. A soil left to, or returning to nature, such as that of the most northern Africa after the Arab conquest, is ever harmful; the Corsican mâquis, the Indian jungle, the African brush, the Australian bush, etc., are among the strongholds, and so to say the lairs of disease, especially of malarial disease.

Moreover, the winds that blow over a country exercise the greatest of all influences on climate and vegetation, and consequently on health. There are parts of northern Africa, as of Asia, of America and of Australia, and even limited parts of Europe, where a progressive population can never dwell, while the physical causes actually at work exist.

In the coast region of Algeria the same communes, nay even the same towns frequently exhibit different climates in their different parts. Thus, Algiers itself has distinctly two local climates: that of the Bab-eloüed and Marengo quarter is more bracing, that of the Bab-Ozoun and Isly more relaxing. These differences are of great importance to the sojourners generally and especially to invalids passing the winter in Algiers; and they are even more marked in the suburbs of St.

Eugêne with its northeastern and of Mustapha with its exposure southeastern, the latter being under the predominating influence of the extensive Bay of Algiers.

The mountains of this region have generally a dry and bracing air, with severe cold in winter in the higher altitudes, where snows last through many months, and where even cases of frozen extremities are not rare. These highlands would in summer have great attractions and advantages as climate stations if they possessed suitable accommodation for sufferers from the heat, debility, or malaria, prevalent in so many parts of the lowlands. Such sanataria would, in many cases, do away with the necessity of the yearly trip to Europe, habitual with an ever-increasing class of the population.

General climate the sum of the local climates.

The general climate in this region, as elsewhere, is but the sum of local climates, with their differences of heat, cold and dampness. As to the latter, it is noticeable that the atmosphere is almost saturated on and near the seashore during the summer, excepting when the wind blows from the desert lying to the south and principally to the southeast; the dampness being at its maximum when the northeast wind blows; while further inland the dampness diminishes and finally disappears. Thus, on the seashore and in its proximity the air contains less moisture in winter, although it is the rainy season then and the moisture is most manifest; that of summer being more perfectly dissolved in the air, and (excepting when the northeast winds blow) being recognized more readily by the hygrometer. The rainy winter months are naturally the damp months in the interior.

Algeria and Tunisia were well-wooded and healthier in ancient times.

In the prosperous days of old, Algeria and Tunisia were relatively thickly wooded, as were most of the countries bathed by the Mediterranean, and they were doubtless more healthy than now. The mountains and hill-sides, the plains and alluvial levels of the Tell, as well as some parts of the high plateaux, have appropriate soil for trees, which in the former region would still abound if not systematically ruined by the fires kindled by the Arabs,* and the abuse of pasturage, their almost universal waste of wood, resins and barks, among which may be cited valuable cork and tannin barks.

Extent of woods remaining as compared to that of France.

Actually the fourteen million hectares of the Tell have less than fourteen hundred thousand hectares of forests left, offering scrub or brush, and less frequently, although there are fine exceptions, forest trees; as compared to the seven or eight million of

* And yet new growths frequently spring up from the ashes of these fires, under the teeth of the cattle, so to speak; but only to be fired again to produce new pasturage, until finally in this weakly and intermittent existence the beneficial influence exercised on the climate by trees is reduced to a minimum.

hectares of generally better woods remaining in France, with its surface of about fifty million hectares.

The above fact is quite sufficient to justify the alarm-cry of the Ligue du Reboisement, which, alas, has so far been "vox clamantis in deserto."

Consequences of the ruthless destruction of trees which is still going on.

This ruthless destruction of forests, groves and frequently of scattered trees is still going on and is the main cause of the diminution of the rainfall, the exhaustion of the soil and of the consequent unhealthiness of many sections.

Other causes of agricultural decadence and unhealthiness.

Other causes of agricultural decadence and of unhealthiness have manifestly been at work in northern Africa since the Arab conquest, such as the waste of manure, which is left to breed disease around the gourbis and douars, the want of proper alternation in crops, the superficial mode of tilling and the always incomplete cultivation of even the small surface that the Arab deems strictly necessary for the maintenance of his family and domestic animals, his calculations (?) being based on an average crop.

This is not true of the Kabyle mountaineers, a different and thrifty race, comparatively progressive and who, like the Swiss, cultivate in a primitive way, it is true, yet very generally, all their soil.

Urgent reasons for replanting of trees.

To sum up, of all countries, Algeria and Tunisia, so sparsely inhabited as compared even with the less densely populated nations of Europe, require to be well provided with wood on account of the general dryness of the climate (except on or near the seashore), the unequal distribution of the rain-fall, which occurs only during the cooler months of the year, when the heavy downpours are in a great measure wasted by the impermeable nature of the soil on the Tell, where the head-waters are torrents, and the lower and more level parts of the small rivers lose by evaporation much or sometimes even all of the water retained for any length of time in summer ; woods are needed also on account of the great variations in temperature and dampness before mentioned, and which in the middle and southern zones produce nycthemeral differences of as much as forty and even fifty degrees (centigrade), while in the northern, the hygrometer attains its extreme recording limits, now under the influence of winds immediately laden with the moisture of the sea, anon subjected to the parching action of the desert. Not only should woods be protected in these colonies, but as many trees as possible should be grown ; for is it not an axiom in climatology that (except in countries lying in the path of damp winds) a large proportion of woods is indispensable to that equable distribution of heat, cold and dampness which produces successful agriculture, a healthy climate and general prosperity ?

II.

Chronological Facts as to the Growing of Eucalypti in Algeria and Tunisia.

Date of introduction of Eucalypti into northern Africa.

The first seeds of eucalypti consigned to the earth in northern Africa were sown in the Jardin d'Essai of Algiers in 1862, by Mr. Hardy, director of the botanical garden thus named, and in the same year by the Comte de Belleroche, who procured them from the director and sowed them in his property in the Commune of El Biar, four miles from town.*

Successive experiments in growing them as a preventive of malaria.

These experiments having succeeded, the trees were soon grown to prevent malaria, still so prevalent throughout northern Africa, and which made most cruel ravages in Algeria between 1867 and 1876, while immigration and the development of the colony were receiving their greatest impulse.

The importance of preserving the public health where satisfactory, and of improving it in the more numerous districts where conditions and circumstances were against it, was, at this time, more generally recognized by the government and the people. The "Ponts et Chaussées,"† the important companies and societies, corporations, municipalities and many private individuals grew eucalypti in the principal settlements infested by the disease, believing that they had at last discovered a panacea against the evil.

In 1868 Mr. Ernest Lambert, inspector of the forests of Algeria, sowed a grove on the Bouzareah mountain, above Algiers, where now is the forest, or rather wood of Baihnen. Then Dr. Marés, at Boufarik, planted a grove on his farm, reporting to the Société d'Agriculture seven years later that the health of his neighborhood was satisfactory. Malaria in its worst forms had constantly prevailed there until then *and until the land had been successfully drained.*

During the two succeeding years, the Société Algérienne planted 100,000 eucalypti near Ain-Mokra, a village on the shore of Lake Fetzara.

The mining company of the Mokta soon followed with many still larger plantations in the same region, where the public health improved towards 1875, the mines being thenceforth worked during the summer, an impossibility until then, owing to the excessive mortality among the workmen, due principally to pernicious forms of malaria.

The latter plantations remain among the most extensive in Algeria, and offer a striking instance of the frequently great aid given by eucalypti against malaria. Thick curtains of the trees were grown between the lake and the village, while, at the same time, a draining canal was cut in

* Now known as El-Afia, and belonging to the author.

† Government engineers, entrusted with the construction and repairing of roads and bridges, and the buoying of harbors.

the shallow bed of the lake, sufficiently deep and wide (so thought the engineers) to carry off the stagnant waters and dry up the swamp. This result, however, was not attained, but yearly thenceforth the waters of the lake were emptied early enough in the spring, and before the summer heats, for the spongy shores to be covered with an herbaceous vegetation offering here and there comparatively fair pasturage. The coincidence of this partial draining with the planting of eucalypti does not permit the conclusion that the improved sanitary condition of Ain-Mokra is wholly due to these trees.

At Maison Carrée, Cardinal Lavigerie and the white Fathers, as well as MMs. Saulière, Cordier, Trottier and others sowed and planted, the first large the last small, groves of eucalypti, with a marked improvement on the health of the community, which, however, still remains far from good.

These enterprises were rapidly followed by many others, and now most Algerian villages, especially if in malarial districts, have more or less extensive groves or avenues of eucalypti, and many farms are also well provided with these trees.

III.

General and Special Advantages Claimed for Eucalypti. Limitations as to the Uses of and Objections to Them.

Advantages of trees in general, including eucalypti: shelter, good effect on the morale and on health.

Among the advantages of trees in general, shared to a certain extent by eucalypti, is the grateful shade procured in hot countries to dwellings, and to cattle, and other domestic animals.

Trees also, including eucalypti, gratify the eye, and the latter have totally changed the aspect of the plain of the Isser river, since they have been grown around its villages and farms. This is not merely an æsthetic result. The fact has its practical importance as acting directly on the morale and therefore indirectly on the physical state of the colonist. For trees form in the barren regions almost the only objects on which the eye rests with pleasure, recalling the triumph of man over desolate nature, diminishing in the heart of the pioneer that terrible longing for less stern realities and cherished scenes in the past, which, if not checked in time, opens the door to disease, even in the most robust constitutions.*

Forests cause the winds to ascend and produce rain.

Another general advantage of trees, particularly of eucalypti, is that forests, like mountains and other barriers, as is well known, when opposed to the wind force it to rise, dilate and cool in the higher and more rarified layers of the atmosphere, whence result con-

*We remark incidentally that in Algeria and Tunisia trees are not more numerous than at the time of the French conquest; they are fewer in fact. But trees, especially eucalypti, have been grown judiciously, where most serviceable to health. The cultivation of the vine has also accomplished much good, more even than eucalypti, because so much more extensively planted.

densation, saturation of the diffused aqueous vapors and finally rain. If, as Mignet says: "A forest is worth a mountain to produce rain," then the higher and more numerous the trees, as the higher and more extensive the mountain, the greater the precipitation of water, *ceteris paribus.** Scrub growths seem to exercise little or no influence on the rainfall, as witnessed in Greece, northern Africa and elsewhere, where this wild vegetation is principally composed of lentisci and dwarf palms, while we observe that the few million trees grown in Egypt under Mehemet Ali and his successors have brought back rains unknown for ages. This is doubtless a fair inference and not merely a coincidence due to other, such as cosmic causes.

Special advantages of eucalypti. Rapid growth.

Among the special advantages of eucalypti, one of the most important for the colonist, who can ill afford to wait long for a result from his labors, is their rapid growth, as compared to that of other trees suitable to this climate, excepting perhaps some acaciæ mimosæ, as shown by the following table approximately correct for an average appropriate soil and exposure:

Age, Years.	Height, Metres.	Circumference, Metre.
1	3	0.10
2	5	0.15
3	7	0.30
4	10	0.40
5	13	0.55
6	15	0.75
7	17	0.90
8	19	1.10
9	22	1.45
10	25	1.60

Resistance to heat and to slight frost.

Moreover the trees thrive where no others will, in the bad lands of these colonies, generally resisting great heat, and several species withstanding relative cold and even slight frosts and snows, as in Australia.

Antimiasmatic action.

To their balsamic odor† is perhaps due an antimiasmatic action on the surrounding atmosphere; and certainly the constant evaporation through their leaves of the dampness taken up by the roots is a most important agent of improvement for soils needing to be drained, while these

* Bare mountains lying in the path of damp winds naturally produce torrents and landslides instead of the useful rains occasioned by wooded mountains.

† This balsamic exhalation from the young shoots, twigs, the leaves and fruit is due to an essential oil similar to that of cajeput, which being oxidized by the air, produces ozone, and which, when refined, gives eucalyptol, a sort of camphor in composition and chemical properties, most serviceable as a febrifuge, tonic stimulant, aseptic and antiseptic.

trees have not the inconveniences of some other hardy trees of a slightly less rapid growth, but also useful for draining, such as plane trees, to which are ascribed (?) many cases of conjunctivitis and keratitis, prevalent in Algeria, Tunisia and throughout the East generally.*

Frequently malaria is not due to the soil on which a village or farm is built, but to the neighborhood. In this case a heavy curtain of eucalypti interposed is always useful and often sufficient to arrest the disease. Of course the swamp, or whatever be the nature of this infectious soil, must not be too extensive or pestilential, and the curtain must be of sufficient extent and thickness.

They form open forests.

The eucalypti form open forests, free from underbrush, that great temptation to the incendiary shepherd, who sacrifices health and well-being to a scant resource in actual pasturage for his flocks (see above the effect of burning down trees). If the subsoil be compact, the roots return to the surface; if permeable, they remain sometimes deep enough to allow a few scant and coarse grasses to grow between and under their shade, if the trees are far enough apart.

Their seeds prolific.

The seeds are light and fertile and readily disseminated by the wind, thus propagating their species and extending plantations.

A permanent benefit to the atmosphere.

The foliage is perennial; its benefit to the atmosphere (hygrometrically, electrically and antimiasmatically) is permanent.

They are killed with difficulty.

Besides, many species are killed with difficulty, and when destroyed above ground by axe or saw send out numerous shoots from the stump; at first easily broken off, but finally firmly fixed, and during the first three years or so giving leaves similar to those of young trees of their age; that is, lighter in color, more flexible, sticky, cordiform, etc., and possessed of greater antimiasmatic virtue than the leaves of older trees.

A great protection to land against wind.

It is well known that the protection of land against wind by an obstacle interposed between it and the wind is directly proportional to the height of the obstacle and approximately to twenty times that height. Therefore, eucalypti protect a much wider tract than most other trees against strong or otherwise harmful winds, such as the blighting sirocco. With a height of forty metres they protect a strip of four-fifths of a kilometre in width, the highest indigenous trees not protecting more than half this surface. The height to which eucalypti rapidly attain is, therefore, a sufficient reason for preferring them to other trees, except some Acaciæ, Mimosæ, to protect land against winds. Alternate rows of eucalypti of appropriate species can be judiciously cut down near the ground

* At Boufarik the great improvement in public health is due to plane trees, and mainly to the thorough draining of the marsh on which the village is built, and where hundreds of colonists lie buried.

ed, so as to afford protection by the branches sprouting ilated stumps against wind passing between them and the of the rows left uncut.

Finally, ashes of the eucalypti contain more potash than those of most European or North American trees.

For kindling and firewood, as fully described further on, most eucalypti offer no advantages, although when other woods are scarce and dear, and constituting a resource in these colonies against the ever-increasing price of

Naturally eucalypti have their limitations, as has every useful plant in nature, and it is a well-known fact that they have not materially improved the unfavorable conditions of disease-breeding soil and atmosphere in the oases, where the former remains undrained ed undrainable, except at the sacrifice of fruitful vegetation, lost hese favored spots in the immense desert of ever-heated sands. even the most extensive forests of eucalypti cannot neutralize the of very large swamps or of flatlands inundated only throughout the , as is the bottom land containing Lake Fetzara, already mend, where the trees cannot be planted with success, either on account he excessive moisture of the ground or by reason of its brackishness lting from the great evaporation.†

t would, indeed, be expecting too much from eucalypti to count upon ir counteracting in Northern Africa all the evil influences at work in y parts, and which in other countries they have been vainly expected overcome.

Italian reports conflicting.

The Italian reports are not generally favorable to eucalypti, nothing decisive, it seems, having been ascertained as to their superiority over all other trees n rendering less unhealthy the immense swamps of the Roman Campagna. It must be conceded that the climate of Italy is less favorable to these trees than that of the Algerian and Tunisian coast regions. However, as noted by De Pietra Santa,‡ "Malaria remains prevalent and

* Mr. E. Lambert, before quoted, claims other special advantages for the eucalypti, such as their immunity from the mandibles of the locusts, who devour other vegetation and even linen; and he mentions the protection their shade would afford to the thrush, black birds and other locust-eating birds if these trees were more extensively grown in the barren plains. He also claims that their foliage and bloom would feed the honey bee, as in Australia, whereas apiculture is now generally confined to the mountains, which are better wooded and less parched in summer, when, in spite of the heat, the insects remain active in this climate.

† "*Eu. rostrata* lives in water containing as much as 1 per cent. of chloride of sodium, but with as much as 1.50 per cent. good results are rare" (Dr. Trabut, Professor of Natural History at School of Medicine of Algiers).

‡ Pietra Santa, "Assainissement de la Campagne Romaine," *Journal d'Hygiène*, 1881-1883. Also *Genie Civil*, May, 1883, Vol. iii, p. 312.

severe in the very districts of the Campagna of all others where it was expected that the disease would have been stamped out, so to speak, by the general planting of eucalypti, especially when, as was the case in many of these places, vigorous cultivation of the soil was added to their expected action."

Australian reports prove a limited antimiasmatic action against powerful causes of malaria.

If now we turn to Australian reports, we remark, as recognized years ago by Prof. Liversidge, of the University of Sidney, that: "Malaria is far from rare in the vast forests of eucalypti of Australia." Although without doubt these trees have always a beneficial action, this is not sufficient, as previously stated, to overcome the powerful causes of unhealthiness that are at work in many places. Referring to this point, Tomasi Crudeli* justly remarks that: "If all malarial soils had the same chemical composition and were similar topographically (and we may add if they had the same climate), then, perhaps, these trees could be expected to improve the unhealthy soils, so as greatly to attenuate or even to eradicate the disease, if at the same time all the diverse modes of improvement which have succeeded in rendering some of them healthy were applied; at least, we could only be justified under such circumstances in expecting a good result. Unfortunately, malaria is bred in very dissimilar soils, and we even recognize its presence on the granitic plateau of Castille. So that systems of soil improvement applicable to some malarial regions are useless in others. Until now we have proceeded empirically wherever we have introduced eucalypti, and such will be the case until a long series of scientific observations and researches, combined with practical experiments, shall have furnished exact information as to each distinct variety of soil which produces malarial poison."

If such be really the fact, let us trust that the dawn is breaking, and that each ray of light thrown on the subject even by such short papers as this (be the ray never so weak) may, when collected into a beam, aid us in seeing where the truth lies.

Objections to eucalypti as being ugly, as being deficient in shade, as twisting their fibre to the left, as not growing with other trees and as not being remunerative.

Objections have been and are still urged against eucalypti. We will only refer to them here, adding a word or two of refutation. This first objection is that they are ugly. This, however, is only relative, and does not extend to all species, some being quite ornamental. The second is that their leaves hang vertically and give incomplete protection against sun or rain. But such protection is preferable to none, surely. Another is their strong tendency to twist to the left,† which greatly interferes with their being sawed into

*Tomasi Crudeli, "La malaria de Rome et l'ancien drainage des collines Romaines." Lecrosnier, 1881.

†This levogyration, which constitutes the main objection to eucalypti, after the consideration that they are unremunerative, has never, as far as known, been explained satisfactorily. It is, however, much less manifested, as here noted, in close and extensive plantations, and there is a marked difference among the species as to twisting. But why is this twisting ever to the left, without regard to the direction of the wind?

planks; but this twisting can be lessened in many cases by growing the trees in close and extensive plantations, which gives most of them proper protection against the winds. Yet another objection is that eucalypti will not thrive generally when intergrown with other trees, and will interfere with the other trees and even kill them off; or, more rarely in these colonies, that they will be injured by the other trees. Both of these facts can be prevented by leaving sufficient space between eucalypti and the other trees.

The principal and insuperable objection to eucalypti requires also but a simple mention here: there is no money to be made from them, or, at least, such is the experience of the growers until now, the trees having been introduced into Algeria and Tunisia more than a quarter of a century ago. Those who recommended their being grown by others for a large profit have benefited by being prematurely rewarded by the government for their zeal.

Alas! that favorable prophecies, with all the calculations to support them, should have proved fallacious.

IV.

Species and Varieties of Eucalypti Most Serviceable in Tunisia and Algeria.

Among the very numerous species and varieties of eucalypti, our choice is founded on the recent study and actual knowledge of the trees. *Eu. globulus* (blue gum) grows well enough in generally dry soils,* and yet is especially suited to damp subsoils; its leaves and fruit are rich in essential oil and it is abundant in its indigenous soil, Australia. We owe the fact of its being the first species introduced into northern Africa to these advantages, as mentioned in our second chapter; also to the fact that there was at the time a relative, if not absolute, ignorance of the merits of the more valuable and equally hardy or even hardier species (which are still not sufficiently known in these colonies). But its wood is inferior for any purpose, as is fully stated elsewhere, and the red gums have been generally preferred within the last few years.

We refer at length in our last chapter to the many qualities of *Eu. marginata*, which is as yet so extremely rare as to be scarcely noticeable in a practical nomenclature of species found here.

Among the most remarkable species of red gums grown here are *Eu. rostrata* and *Eu. resinifera*, and numerous hybrids or crosses of these species. The former, when extensively grown from the seed and planted out, furnishes a good wood, withstands the dryness of the summer in the interior, seems to be one of the most resistant of trees, and reproduces itself spontaneously in the coast region (where, probably, it will soon be-

* Nevertheless it sometimes dies suddenly without apparent cause after attaining a considerable size.

come acclimated). The latter withstands intense drought and requires deep and dry soil.

Besides the above species, among the most robust and advantageous to northern Africa, according to Dr. Trabut, are the following: *

Eu. tereticornis.
Eu. amigdalina.
Eu. botryoides.
Eu. colossea (*Eu. diversicolor*).
Eu. cornuta.
Eu. corinocalyx (dry soils).
Eu. gomphocephala (still rare, but most useful).
Eu. goniocalyx.
Eu. leucoxylon (*Eu. sideroxylon*).
Eu. maculata.
Eu. mülleri.
Eu. occidentalis.
Eu. polyanthema (Shaw), *Eu. populnea* of Müller, *Eu. populifolia* of Hook, etc.
Eu. rostrata (brackish swamps).
Eu. robusta.
Eu. romeliana (hybrid from *Eu. botryoides* and *Eu. rostrata*, leafy and strong, obtained by Dr. Trabut).
Eu. rudis (large capsules).
Eu. soligna.
Eu. viminalis.

V.

Where, When and How to Grow Eucalypti in These Colonies.

Where to grow them.

Eucalypti, like *Acaciæ*, *Mimosæ*, and plane trees, thrive in countries where there are but two defined seasons ; yet in Algeria and Tunisia they are only to be grown in the coast region, especially in the larger valleys and on the hillsides. Neither the extreme cold of winter on the high plateaux of the central zone, nor the extreme heat of the southern or Saharan zone and the changes between the temperatures of day and night, are suitable to them. Adaptable to widely different conditions of temperature, according to species and to the composition, depth, dryness or dampness of the soils in different parts, yet, in the words of Sir Lambert Playfair, † it would be

* Dr. Trabut, Professor of Botany at the Ecôles Superieures, Algiers.

† Sir Lambert Playfair, Consul General of Great Britain at Algiers, Report on the planting of Eucalypti in Algeria, May 16, 1877, No. 21.

"as useless to attempt to grow them in the Tropics as it would be in the north of Scotland."

For species suitable to special soils see preceding chapter. Generally speaking, eucalypti should be grown throughout Algeria and Tunisia, preferably in swampy localities, on the shores of lakes, around ponds either shallow or brackish and partly dry in summer, in damp bottom lands, on the banks of water courses which are sluggish or frequently changing their beds (as are most north African rivers, which often ruin whole valleys that might be fertile under other conditions), in places exposed to landslides or slips, for they are generally not on a large scale, although frequent on account of the abundant clay of the coast region. We have seen also that they aid in protecting villages and farms against noxious winds, sun and the malaria, whether bred *in locis* or in the neighborhood. Finally eucalypti are advantageously grown in any appropriate soil of little value for other purposes, if a judicious choice be made among the species. Whatever be the locality chosen, the surface soil must be permeable and otherwise suitable; the subsoils, if compact, force the roots to spread out mesh-like to considerable distances, sixty metres as we have measured, in the direction of water or of deeper and better or damper soil.

Where not to grow them.

Without a ditch of a couple of metres in depth being dug as a separation between eucalypti and the other more valuable plant, no eucalypti, particularly not *Eu. globulus*, should be grown near these plants (orange or other fruit trees, vines, flower beds, etc.), nor too close to a spring (always most precious in these colonies), a well, a reservoir, a building or any useful wall, as eucalypti send out roots which absorb the nourishment of other plants, and sometimes ruin constructions even of cement.

Three modes of propagation.

Eucalypti are grown from seed, either sown *in loco*, in the open field where the trees are to remain, or, preferably in Algeria and Tunisia, the seed should be sown in pans, the young trees being planted out properly and at the proper time; or they are grown from young trees.

The seeds take from fifteen to twenty days to germinate, according to soil and season. They are small, light and generally fertile. They should nowhere be covered by more than a centimetre of finely divided earth.

Water is generally scarce in Algeria and Tunisia, and artificial irrigation being expensive, cannot be attempted, if the plants are to be grown on a large scale.

Preparation of the ground for sowing and planting.

For both sowing and planting, the ground should be prepared several months before the seeds or the trees are consigned to it. The soil should be broken up by a subsoil plough to a depth of 0.05 metre or more, when possible, and all foreign growths removed.

Sowing in the open.

Shortly before sowing in the open, the ground should be ploughed crosswise, that is in both directions, and reploughed lightly in furrows 1.5 metres apart. The seeds should be carefully deposited every two steps (or at intervals of 1.5 metres) and covered with a thin layer of fine earth. Of course, this entails irregularities in the interspacing of the shoots, as many seeds do not germinate, being blown or washed away or washed under, and the young plants of the same species grow more or less rapidly, according to the quality of the surface soil, and in a lesser degree to the nature of the subsoil in various places in the same localities, and moreover the growth is less rapid for some time than when young shoots are planted. This sowing in the open, which should take place at the beginning of the rainy season, appears to be cheaper than sowing in pans and planting out the young trees a few months old, the labor being so much less, but in the end it is dearer as so many seeds do not germinate, and the sowing has to be renewed frequently.

Sowing in pans to plant out the shoots.

The seeds are preferably sown in pans or boxes, and the young trees planted out at the proper age and season.

"Prepare a compost of vegetable mould and river sand very finely sifted. Fill the pots of 0.15 metre in diameter, press the earth lightly and evenly with a small zinc cylinder of about the same diameter as the pot. Scatter the seed on the surface so as nearly to cover the whole of it, then, with a very fine sieve, which may be a zinc cylinder similar to the other but perforated with very minute holes, sift just enough of the compost on the seed to cover them and no more. Press this surface again lightly with the first cylinder and water with a watering pot, the rose of which is perforated with the smallest holes which it is possible to make. This should be done in early May, so that the trees may be planted out at the first rains of autumn when the ground is moist. Within fifteen or twenty days the seeds will have germinated, and in about six weeks the plants will be ready to put out. Weed off as soon as the trees have produced four leaves, and transfer to other pans of 0.1 metre in diameter, to be kept in a shady place for the first day or two, and then transfer to a sunny position; water during the summer just sufficiently to prevent them from dying. The great object is to retard their growth during the summer so as to keep them small and prevent their roots from becoming matted inside of the pans.

A second sowing may take place about the middle of September, so as to obtain young plants ready to be put into the ground about the beginning of spring. In some respects this plan is preferable to the other, and it is always so when the plants can be watered in summer. The young trees have a shorter time to remain in the pans, and their roots run less chance of becoming matted; but often, when the rains cease early in the year, they have not become sufficiently rooted in the open

to enable them to resist the heat of summer without occasional irrigation.

"The Eucalyptus is a plant that does not stand being kept long in a pan; its roots grow with as great rapidity as the rest of the tree, and, if they are allowed to be contorted round the inside of the pan, the tree does not recover from this unnatural condition of things and seldom grows straight and healthy."

Planting in the open on a large scale.

As previously stated, as soon as the ground (which has been broken up and freed from other growths, late in the winter or early in the spring while wet) becomes again impregnated with the rains of autumn, plough and plant out the young trees of three to five months' growth (which have often five to eight leaves each), at interspaces of four metres in trenches, and as they increase in height, progressively fill in the trenches, till in six months they have entirely disappeared, and instead of a depression, the earth becomes piled up round the stem of the young trees; this serves not only to keep the roots moist, but to prevent the slender stem from being blown over by heavy winds against which eucalyptus should always be protected as much as possible to prevent twisting and a slow growth.

It is well to give each plant a good watering when put into the ground, but they will generally not require another (?).* The soil should be kept free from weeds and open for the first two or three years, which may be conveniently done by passing a cultivator between them in each direction once or twice a year. After the third year they may be left to themselves and will require no further care.

"Weakly specimens are eliminated wherever necessary and their places filled with hardy plants, until a full plantation of trees is obtained from four to five metres apart."

Planting on a small scale.

When eucalypti are to be planted on quite a small scale, instead of trenches, holes of a cubic capacity of 0.5 metre may be made; but this is not to be recommended in the open field, as the heavy rains are apt to fill up the holes with earth and smother the plant, instead of being carried off by the open trenches above described.

Definite aspect of a plantation.

"By judicious management plantations can be obtained in which the trees are about four metres apart, and after ten years or so, every alternate row in its entirety may be cut down, leaving the remaining trees at eight metres apart."

* It sometimes happens, when the rains cease early in the year, that the young eucalypti have not become sufficiently rooted during their short sojourn in the open ground to enable them to resist the heat of summer without occasional irrigation.

VI.

Commercial Value of Eucalypti in Algeria and Tunisia.

Pecuniary profit from the trees generally.

The retail price of ***Eu. globulus***, much the most abundant among eucalypti in Algeria, when cut up for fuel and sold in Algiers is $0.50 a quintal (100 kilogrammes = 220 pounds), and yet we have been offered by the trade for full-grown trees the same sum, all expenses of cutting down, sawing and splitting into hearth-logs, as well as of carting to town being assumed by the buyer.* The road to town is good, down hill and only four miles long, and the cost of transportation is estimated at about ten cents a quintal. If the road to market is not very short and good, the trade will not buy standing eucalypti at any price, as there is no profit, and frequently a positive loss in the transaction, and in the immediate proximity to any good market the purchaser has to pay too high a price for his land to grow eucalypti for sale.

Thus we see that the business scarcely exists at all on any scale worth a longer notice here. And yet firewood is generally wretched in the coast region, good wood being procurable only in the mountains where, with the exception of the several military roads which are admirable, the roads are few and bad. All fuel is therefore relatively dear, because until now no coal mines have been worked, although several are said to exist in the colonies.

In the towns and even in Algiers old boxes, rafters from torn-down houses and ragged roots of lentiscus are offered and bought as fire wood.

Details as to expenses of growing the trees, and margin of profit or loss.

Counting 800 trees to the hectare (2 acres 1 rood 35 perches) left after ten or twelve years, if the trees are then marketable (as they rarely are under the most favorable conditions and circumstances), we have, at say 50 cents each, $200 for the product of an hectare for ten years, or $20 a year, that is, about $9 a year for the acre. From this sum, if we subtract the cost of growing the trees in the most economical way, which is one-twentieth if the trees are grown from the seed planted *in loco* (as previously noted), and which may be estimated at $4 a year per acre; and the interest on the price of the land and other incidental expenses, we find no profit left, or even a pecuniary loss, unless we start with very cheap or free land, most favorably and exceptionally well situated and with 2000 trees per acre, to be weeded out during the first five or six years: and unless we can sell these younger trees, which is a very rare occurrence, the trades preferring other woods

* These trees were thirty years old, but under the most favorable conditions the trees would possibly have brought the same price at fifteen.

for the numerous uses to which eucalypti are put in Australia, doubtless for want of better wood.*

A small market for the accessory products of eucalypti.

Not only is there, generally, no profitable market for the wood of eucalypti in Algeria and Tunisia, but there is a very small sale of the undoubtedly important accessory products of these trees.

From the leaves, twigs and fruits, giving the essential oil, there is still a little profit. For the oil when produced by the colonist the demand is relatively small compared to what it should be, high prices being asked for it by the retail dealers.† As to the tannin, it is not used in Algeria and Tunisia, nor in France, as it is in Spain and Portugal for the tanning of leather; while the tannin of Mimosæ, or mimotannic acid, is recognized as a most efficient aseptic and antiseptic, rendering valuable services in therapeutics, and successfully used in diphtheria by Dr. Bourlier, the discoverer, and others, as prepared by C. Brenta, of Algiers.

Possibility of some choice species being peculiarly profitable in the future.

Perhaps some choice species of eucalypti, such as *Eu. marginata, Eu. leucoxylon* (the *black* variety), will redeem the reputation of the trees as a source of pecuniary profit, when grown under the most favorable conditions and circumstances. Until now, however, nothing worth recording has been accomplished with this

* In Australia, as stated by M. Ernest Lambert, ex-Inspector of Forests in Algeria, eucalypti are in general use for manufacturing such implements as pitchforks from young trees two years old, whip handles, the handles of spades, hoes, sledgehammers and other articles of daily use. Three-pronged pitchforks, always relatively dear, are readily procured from the young trees, the stem of which is broken off or cut off and the leaves of which are stripped from the two side branches of such trees, or a branch is pinched so as to distribute the sap as regularly as possible in the three forks thus obtained. At three and four years old the trees make carriage poles or shafts, ladder poles, fence poles and rails, wheel spokes and other articles too numerous to be recapitulated here. At five years telegraph poles are obtained, which the above-named author and others affirm to be more durable than pine poles, and not to need to be injected by a preservative substance to enable them to last. The pine poles are only procurable from trees of twenty-five years' growth, during which, say the above-mentioned authors, eucalypti give five fine poles to one tree. For supports in mines eucalypti have also their places well defined, as, indeed, for railway sleepers, five or six of which are to be had from trees of seven or eight years of age. At nine they serve as piles for docks and quays. When cut up at this age they are serviceable for wheel naves, carriage brakes and drays and what not, according to the same panegyrists.

† This oil is worth about $3 a kilogramme at Grasse, France. The parts of eucalypti employed in its manufacture yield 2 per cent. in weight, while 10,000 kilogrammes of the petals of roses and 700 kilogrammes of those of geranium yield but a kilogramme of these more valuable oils.

Many products, of doubtful origin, actually used in perfumery under fanciful names, of supposed Japanese and other origins, seem to have no other merit (when they are not positively offensive to the sense of smell) than their supposed scarcity and consequent expensiveness. Eucalyptol, if rare or still supposed to be, would doubtless be sought by the extravagant public as an agreeable exotic perfume. It would have the merit of being a clean product of great virtue for the toilette, which is more than can be said of any of these so-called perfumes,—and, united in due proportions with pure white vaseline and good toilette soap, it should be extensively used for toilet purposes.

species, excepting the interesting experiment made by Dr. Bourlier on his farm near Reghaia, where a few of this species have been successfully grown, conjointly with divers Acaciæ and especially with Mimosæ.

Desirability of the propagation of such fine species as *Eu. marginata.*

A fine, strong, inexpensive wood, almost uninflammable and resisting decay, fit for barn and ship building, railway ties, piles, telegraph poles, paving blocks, flood-gates, carpenter's work and even cabinetmaking, such as *Eu. marginata*, the yarrah wood or Australian mahogany is claimed to be, would indeed be a boon to Algeria and Tunisia, which have so far not been blessed with any such treasure.*

Alleged blindness of the public and market to the merits of eucalypti in general.

It is a pity that, with the exceptions mentioned in this paper, the very many merits claimed years ago, and still claimed by some, for eucalypti in general, should remain unrecognized in Algeria and Tunisia by those who have been induced to make the experiment of growing eucalypti for profit. Either the public and the market are blind to the merits of eucalypti, or else the numerous services rendered by these trees are still better rendered by others at present in use for agricultural and industrial purposes, as well as for fuel. It is needless to mention which of these suppositions is the most likely.

On the Remains of the Foreigners Discovered in Egypt by Mr. Flinders-Petrie, 1895, now in the Museum of the University of Pennsylvania.

By Mrs. Cornelius Stevenson.

(*Read before the American Philosophical Society, March 20, 1896.*)

Before entering upon my subject, I must explain that what information I have with regard to this remarkable collection is mainly derived from private letters received from Mr. Flinders-Petrie last winter at the time of this most brilliant of all his brilliant discoveries, and at intervals since then. Very little has, as yet, been published concerning them. The

* Like the reed of the fable, *Eu. marginata* is flexible and bends readily without breaking. A block of 0.5 metre in length and offering a square section of 0.25 metre bears, before breaking, a weight of 1400 kilogrammes suspended from its middle, 900 kilogrammes being the breaking weight of a ruler of oak of the same dimensions. The resistance of *Eu. marginata* to crushing in the same condition is also greater than that of oak (both woods having the same density), and is 350 kilogrammes to the square centimetre of bearing surface; its tensile strength is remarkable, 890 kilogrammes to the square centimetre. Its resistance to parasites is very great, even the terrible white ant cannot perforate its grain, nor does the *Teredo navalis* cause its prompt destruction, as is the case with other woods used in naval constructions, for *Eu. marginata* has been known to withstand the action of the ship worm for thirty and forty years (E. Lambert, above quoted).

report has not yet appeared, and the only sources of information available are a catalogue of the objects exhibited at University College in London last July; some short articles published by Mr. Flinders-Petrie in the *Times* and in the *London Academy* and reproduced in the *American Journal of Archæology*, and a leaflet issued by the "Egyptian Research Account" as a brief preliminary report to its subscribers. These with the private letters above referred to form the basis of this paper.

You are aware that last winter Mr. Flinders-Petrie, whilst working in the neighborhood of the villages of Ballas and Nagada—that is some thirty miles north of Thebes (near the twenty-sixth parallel) on the western bank of the river and on the edge of the desert—made some remarkable discoveries.

In this locality were some Mastaba-tombs of the old empire (IVth to VIth dynasties) and a Mastaba-like pyramid, similar in form to that of Sakkara, with a sepulchral chamber scooped out of the sand bed below, but entirely constructed of natural blocks, selected for size, and in no way tooled or even broken, and therefore probably one of the earliest of such structures.

The Mastaba-tombs likewise offered interesting peculiarities: access to them was obtained through a stepped passage, which sloped down from the north as in a pyramid. Nearly all these tombs had been anciently plundered, and little, save a large number of stone and alabaster vases, was found belonging to their original occupants.

In some of these ancient tombs, however, were discovered burials of strange intruders, the evidences of whose general culture, beliefs and funeral customs show them to have been strangers in the Nile valley. Not a single detail of their culture did they hold in common with the Egyptians. Moreover, their number, which was found to have spread over a considerable portion of upper Egypt, from Abydos to Gebelen, over one hundred miles, whilst their influence was observable from Tenneh to Hieraconpolis, *i. e.*, over three hundred and fifty miles, and the absolute control of the region which they assumed and which is shown by the total absence of any object recalling Egyptian civilization, show them not only to have been invaders, but invaders who once had swept over the region and who, settling down, had lived there for a considerable period, borrowing little or nothing of the people whose land they occupied. As Mr. Petrie wrote in the first outburst of enthusiasm following upon his great discovery: They form "a grand new puzzle and might as well have been found in Siberia or in France for aught of their connection with regular Egyptian antiquities."

This complete wiping out for a time of the Egyptian civilization is one of the most striking features of this remarkable episode, and gives point to Mr. Flinders-Petrie's discovery. In the large number of burials opened "not a god, not a scarab, not a hieroglyph, not an amulet, not an Egyptian bead was found." These people were great pottery manufacturers, and yet, although they settled in a land where the potter's wheel had long

been in common use, all their pottery is hand-made and of form and decoration peculiar to themselves.

An Egyptian town in the immediate neighborhood yielded—in different strata—pottery of the IVth, XIIth, XVIIIth and XIXth dynasties, and presented not one single link with the peculiar manufactures of the intruders. What, then, had become of the Egyptians on this extensive tract of territory and during the considerable period represented by the layers containing variations of the original industries of the invaders?

The kings of the Vth dynasty who ruled over united Egypt were said by Manetho to have come from Elephantine, and vestiges of their power and of that of their successors (VIth dyn.) have been found from the southern frontier of Egypt to the peninsula of Sinai. Even recently, fragments of papyri have been found at Elephantine bearing the names of Rameri and of Noferkara which must be added to the weight of evidence already gathered to show the extent of their empire (London *Acad.*, March 14, 1896). They were powerful monarchs, and, like all of Egypt's strong rulers, they were active in their building enterprises and have left, written on stone, eloquent testimony of their power.

Of their successors, the Memphite kings of the VIIth and VIIIth dynasties, however, nothing remains save a few scarabs bearing names that can be identified with some of those given in the Egyptian lists for that obscure period. Indeed the silence of the monuments is so complete as to become positively eloquent. It is evident that some national catastrophy occurred about that time which caused the dismemberment of the great empire of the pyramid builders and reduced the power of their Memphite successors to comparative insignificance.

Manetho gives five kings for the VIIth Memphite dynasty and twenty-seven for the VIIIth. The Turin fragments give eighteen, and the tablets of Abydos give a selection of fifteen. No doubt can exist, therefore, as to their reigns having occupied a considerable period of time. There is evidence that during the IXth and Xth Herakleopolitan dynasties, Upper Egypt, which—as far as the monumental evidence is concerned—seemed to have been wiped out of existence, reappeared upon the scene of history, and that the princes of Thebes began to assert themselves and to grow in power. Some important inscriptions found by Mr. Griffith in the tombs of the feudal princes of Siût cast a flash of useful light upon this obscure period. These princes, loyal to the kings of the Herakleopolitan dynasty, fought on their side in their wars against the Theban princes, whose increasing pretensions threatened the power of their liege lords. These facts are now all-important in restricting the limits in which must be placed the episode of the foreign intrusion just brought to light by Mr. Petrie's genius. It seems obvious that such an intrusion could not have taken place had the Theban princes been as powerful as they appear to have been under the IXth and Xth dynasties.

That the foreigners entered Upper Egypt after the great period of the pyramid builders is shown by the fact that the Mastaba-tombs referred to

above were usurped by them to bury their own dead. Moreover, in the step-passage of a Mastaba, a burial of the XIIth dynasty was found superimposed upon the remains of the strangers. Here were therefore three well-defined epoch-marking layers, and the fact that brick tombs of the XIIth dynasty were constructed over the ruins of a town occupied by these people, conclusively proves that their presence in Egypt preceded the Middle empire.

Four necropoles and two mud-brick towns extending over an area of five miles yielded the same result as to strata and relative occupancy. It is therefore reasonable to see in this intrusion of a strange race, spreading over so considerable a portion of the Egyptian territory, which it held for so long a period of time exactly coinciding with the monumental break in Egyptian history, if not the explanation of at least an important fact connected with that break; and to venture upon the assertion that a migratory movement of some magnitude took place about 3400 B.C., of which the people whose remains have just come to light formed a portion, and by which the first united Egyptian empire was weakened and brought to an end.

Mr. Petrie, assisted by Mr. Duncan, pursued his investigations at Nagada, whilst Mr. Quibell, working for the "Egyptian Research Account," explored the burials near Ballas, both exploring parties continuing their researches until over 2000 burials were opened and their contents examined and secured. These made it evident that the invaders had long retained their peculiar customs and beliefs: Instead of cutting their tombs in the solid rock as did the Egyptians, they dug their graves in shoals of gravel in the dry water courses of the desert edge; these graves are open square pits of the type of those found at Mycenæ; they were roofed over with wood, and their average dimensions are about 6 x 4 and 5 feet in depth. Their size varies, however, from half to double those here mentioned. Unlike the Egyptians who mummified their dead and laid them stiffly stretched out upon their backs, the body, reduced to a skeleton, here lay in a contracted position turned upon its left side, facing the west, with the head to the south. Every body, or ninety-nine out of a hundred, was found with the head taken off or removed. Short, oblong coffins of coarse pottery, with a lid and resembling a chest, were used. The bodies showed evidence of having been mutilated before burial. In one fine tomb, the bones were heaped in the centre, whilst other bones, the ends of which had been broken off and scooped out as though for marrow, were placed around them. This led Mr. Petrie to suggest that they must have been ceremonial cannibals. In other graves the bones were separated and sorted out.

Large bowls of coarse pottery, such as those exhibited with the coffin, contained ashes, probably of the funeral feast, and Mr. Petrie aptly quotes with reference to this custom 2 Chron. xvi. 14, xxi. 19, and Jeremiah xxxiv. 5, referring to a great burning made at every funeral—a custom probably Amorite. These were placed at the foot, and other jars,

such as may here be seen, and which originally contained liquids—beer, water, etc.—were placed along the sides. As many as eighty vases have been found in one grave, and few interments were provided with less than ten or a dozen. Among these were sometimes found a vase of black incised ware, evidently imported.

Jars of pottery with wavy handles, containing scented fat or its Nile-mud substitute, were placed along the head end, with a rough pointed brown jar in the middle. This type of pottery, which was very common and which gave rise to varieties of forms and uses during the sojourn of these people in the Nile valley, must be regarded as part of their industrial equipment, and is so specialized as to have led Mr. Petrie to suggest that these men were related to the Amorites of Palestine, who used similar pottery and who, he thought, might be another branch of the stock to which these invaders of Egypt belonged.

In bringing these objects to your notice, I am laboring under serious disadvantages and I must claim your indulgence should it so happen that I cannot make all points of detail clear to you. Although the collection reached here early in the winter, lack of proper space to work it up and to display it with safety, prevented my unpacking it until now, and I have not had a chance to study each specimen as it should be studied. This is all the more to be regretted as the material is quite new, and as, for the first time in the course of our much *more* than satisfactory relations, Mr. Flinders-Petrie, owing to pressure of business, was unable personally to superintend the packing, so that I have had very little to guide me in my identifications save my own limited experience and the general indications furnished in Mr. Petrie's letters. The types peculiar to these strangers are, however, as a rule readily recognized.

The main difficulty has been with the alabaster and stone vessels, of which we have a great quantity. These are principally derived from the Mastaba tombs of the old empire, and in sorting them there lies therefore some danger of confusion, especially where, as in the later layers of the invaders, a certain overlapping took place. I have, however, only brought here those specimens of Libyan stone work as to the origin of which I can entertain no doubt: Elongated vases of various dimensions with useless ledge-like feet too small for use, intended to be suspended by means of long tubular handles, a frog of breccia, and various other types which have no Egyptian equivalents. These stone vessels are hand-worked and show no trace of the turning-lathe. The material which I have not been able to determine with certainty must remain until Mr. Petrie's full illustrated report is published, when each group of objects in our collection will, no doubt, find its proper place.

Most of the flint implements now before you are from the invaders—these are oval in shape and equally worked on both sides. There are, however, a few dark weathered flints found upon the top of the limestone plateau, some 1400 feet above the Nile—all of which show signs of a longer exposure than that to which were subjected those flints to which

we know can be assigned more than 5000 years of existence under similar conditions. These are regarded by their discoverer as Palæolithic ; among them are two whitened flints of the pointed type, thickly patinated, also regarded by Mr. Petrie as Palæolithic.

The stone work of these people was, as may be seen, of the very highest order. We have here some flint bangles, one of which is perfectly cut to less than the eighth of an inch in diameter. Some of the finest blades excel not only anything done in that line by the Egyptians, but are unsurpassed by any ancient neolithic workmen. The exquisite regularity of the surface flaking and the fine serrated edge of some of their tools is startling in its perfection. Some forked stone lances used in hunting the gazelle are both curious and beautifully executed, and their numbers show their owners to have been great huntsmen.

It is more than probable that some fine specimens of similar workmanship found in Egypt from time to time and which have been brought into various museums were, in reality, relics of these people. Mr. Petrie has already called attention to a fine blade belonging to General Pitt-Rivers' collection and which is set in a handle of undoubted Egyptian manufacture. This is certainly the adaptation of an older blade.

These interlopers also used copper tools. Other metals such as gold, silver and lead were apparently known to them, although valued as rare products.

In their pottery they seem to have often aimed at reproducing the stone forms common among them, and even at imitating the very substance, such for instance as the limestone breccia, which they copied in splashed pottery, of which we have here a beautiful specimen.

The red polished and the black and red polished wares are the most common manufactures. Animal forms and curious devices were produced. The black and red is very distinctive. This is of the same material as the plain red, but is harder and is given a higher polish. The forms also differ, and are generally remarkable for the elegance of their proportions. According to Mr. Petrie, the black color is due to the "deoxidizing action of the wood ashes in the kiln, reducing the red peroxide to a black magnetic oxide of iron. The brilliant lustre of the black is probably due to the solvent action of carbonyl, due to imperfect combustion, which enables the magnetic oxide to rearrange in a continuous surface."

The effect of this process seems identical with that observed on certain vessels found by Dr. Richter in the lowest stratum of the copper-bronze age in Cyprus and approximately placed by him sometime between 4000 and 3000 B.C. In the collection which we purchased from him some years ago and which contains a part of the results of his own excavations in Cyprus, there is a round bowl to which the above date is assigned, and which is identical in coloring, polish and general effect to this black and red ware; the form, however, is different from that of any vessel in this collection, and a small perforated handle for suspension on one side would in itself draw attention to a difference in the manufacture. It

would seem from this, however, that the deoxidizing process as systematically applied to red pottery for purposes of decoration was a widespread fashion at that remote period.

Some of the pottery of these strangers was decorated with crude figures of ostriches, antelopes, etc., often represented in long lines, in brown on buff and in red upon a lighter red. A very common decorative motive is a long boat with two cabins, an ensign pole and many oars; sometimes the figure of a man is added. The red polished ware, decorated in white lines, "dents de loup," plants and flowers, etc., is imported from the Mediterranean region. It is stated by Mr. Petrie to occur only in a limited range of the territory occupied by the foreigners, and it gave rise to no varieties of type. The shapes of these vases are also peculiar, especially the specimens in which two or three tall, straight stems or necks arise from one base.

The black incised bowls, with white decoration, in lines and "dents de loup," are also imported. No such pottery is known of Egyptian make, although in later times, during the Middle empire, a style of pottery similar, though much finer, appears. A near approach to it is found in the later Neolithic stations of Italy, Spain and in the lower strata of Hissarlik.

In a paper read before the Anthropological Section of the British Association—a notice of which was published in the *Academy* (September 28, 1895) and in *L'Anthropologie* (October–December, 1895, p. 590)—mention is made of a Neolithic station near Butmir, in Bosnia, recently studied and described by Mr. Radminsky, where pottery was found offering a great variety of decoration, among which, by the way, appears a spiral ornament. Figurines showing some artistic aspirations were also recovered. In the discussion that followed Mr. John Evans expressed the opinion that this station probably belonged to the transition period from the Neolithic to the bronze age. Certain holes cut in the clay reminded Mr. Petrie, who was present, of the sand pits dug in Egypt. He said that the pieces of black pottery exhibited by Mr. Radminsky were absolutely identical with pieces found by himself in Egypt and by others at Hissarlik and in Spain, and that he, therefore, would date such a settlement, by this black pottery, from 3300 to 3000 B.C., when it was generally manufactured (*Anthrop.*, October–December, 1895, p. 560).

Among the small objects in our collection are a number of bone combs and tools, one of which, a puncher, has just been identified by Prof. Cope as the metatarsal of a gazelle. We have also a series of slate pallets upon which Malachite, etc., was ground probably for tattooing purposes. These are in the shape of the turtle and fish, besides more simple forms, such as squares and rhombs ; but a larger variety of animal forms has been found, and Mr. Petrie mentions the ibex, elephant and birds among those in his collection.

It is worthy of notice that the taste for symmetry, which prompted the introduction of the double-headed bird design among so many ancient and modern peoples, was already developed among these men, as may be

No. 1.

No. 2.

1.—Stone Vases Typically Libyan. 2.—Black and Black and Red Polished Pottery Distinctly Libyan.

exposure of the latter and the protected condition of the former. But this is not sufficient to account for the marked differences. Moreover, the shape of the plateau implements is distinctly "palæolithic." They are not intended to be hafted, but to be held in the hand when in use. What is further noteworthy about them is that obviously both are adapted to be held in the *left* hand only. So far as they go, they support the theory advanced by some writers that primitive man was less right-handed than later generations.

The pottery and stone articles from the tombs of the so-called "new race" near Abydos are good examples of their arts. I speak of this with some knowledge, as early last August I examined with much care Prof. Flinders-Petrie's immense collection in London, and had the advantage of his personal explanations. The article that I published in reference to it, in *Science* (August, 1895), was I believe the first original report on the subject in any American periodical. That the "new race" was supposed by Prof. Petrie to be Libyan, that is, Berber, attracted me, as the ethnography of that stock has been a special study with me.

This identification, I believe, will finally be established. If we examine the configuration of the Nile valley and its surroundings, no other theory is tenable, providing the Libyan stock extended that far south of the Mediterranean at a date 3000 B.C. We know they did, and much earlier, from their very early presence in east Africa. The invading "new race" could not have come from the east. The natural highways from the Red Sea to that portion of the Nile valley centre at Koptos, and there few or no specimens of this peculiar art have been exhumed. They must necessarily have entered from the west, and a study of the ancient and modern caravan routes leads inevitably to the conclusion that their last previous station must have been the so-called "Oasis magna" of the Libyan desert. This consists of a series of arable depressions in the calcareous Libyan plateau, which here rises to an average height of about 1200 feet. The central portion of the Oasis is about 130 miles westerly from Abydos, and to it a number of caravan routes converge from the north, south and west. So far as history, archæology and linguistics teach us, this group of cases, as well as the "Oasis parva," opposite the Fayoum, and that of Jupiter Ammon, still farther north, have always been peopled by the Libyans. This stock has not been shown to be connected in culture with the Neolithic peoples of western Europe, and no positive traces of the Berber language remain there, though it is probable that the word "Iberian" (from Iberus) indicates their presence in the peninsula of that name. The conclusion which I urge, therefore, is, that the correlatives of the art of the "new race" will be found in the "Oasis magna." That some of the tombs contain Egyptian and even Mediterranean relics is readily explained by the commerce which it is evident from the figures of their boats they soon established on the Nile.

No. 1.

No. 2.

1.—STONE VASES TYPICALLY LIBYAN. 2.—BLACK AND BLACK AND RED POLISHED POTTERY DISTINCTLY LIBYAN.

COARSE POTTERY, JARS, COFFIN, LARGE BOWLS CONTAINING ASHES FROM THE FUNERAL FEAST.

Stated Meeting, March 20, 1896.

Vice-President, Dr. PEPPER, in the Chair.

Present, 22 members.

Correspondence was submitted as follows:

Letter of envoy from Mr. Robert N. Toppan, Cambridge, Mass.

Letters of acknowledgment from the Royal Society of New South Wales, Sydney (143–146); K. B. Astron.-meteorologische Observatorium, Triest, Austria (142–147); Prof. Dr. F. Müller, Vienna, Austria (147); Oberhessische Gesellschaft für Natur- und Heilkunde, Giessen, Germany (147); K. Sächs. Gesellschaft d. Wissenschaften, Leipzig (143, 146, 147); Marquis Antonio De Gregorio, Palermo, Italy (147); Prof. E. D. Cope (147, 148), Mr. F. Prime, Philadelphia (147); Prof. John F. Carll, Pleasantville, Pa. (148); Lieut. A. B. Wyckoff, N. Yakima, Washington (148).

Letters of acknowledgment (149) from the Laval University, Quebec, Canada; Canadian Institute, Toronto, Canada; Bowdoin College Library, Brunswick, Me.; N. H. Historical Society, Concord; Vermont Historical Society, Montpelier; Amherst College Library, Mass.; Mass. Historical Society, Boston Athenæum, Boston Society of Natural History, Dr. Samuel A. Green, Boston, Mass.; Museum of Comparative Zoölogy, Harvard College, Profs. W. W. Goodwin, F. W. Putnam, Mr. Robert N. Toppan, Cambridge, Mass.; Essex Institute, Salem, Mass.; Amer. Antiquarian Society, Worcester, Mass.; Agricultural Experiment Station, Kingston, R. I.; Providence Franklin Society, Brown University Library, Providence, R. I.; Mr. George F. Dunning, Farmington, Conn.; Conn. Historical Society, Hartford; Buffalo Library, Society of Natural Sciences, Buffalo, N. Y.; Prof. Edward North, Clinton, N. Y.; Profs. T. F. Crane, J. M. Hart, Ithaca, N. Y.; Astor Library, N. Y. Academy of Medicine, Columbia College, Historical Society, Amer. Museum of Natural History, N. Y. Hospital, Prof. Joel Asaph Allen, Hon.

Charles P. Daly, Mr. J. Douglas, Dr. Daniel Draper, New York, N. Y.; Prof. Robert W. Rogers, Madison, N. J.; Profs. W. Henry Green, Charles W. Shields, Princeton, N. J.; Dr. Robert H. Alison, Ardmore, Pa.; Prof. Thomas C. Porter, Easton, Pa.; Mr. John Fulton, Johnstown, Pa.; Linnæan Society, Lancaster, Pa.; Dr. James W. Robins, Merion, Pa.; Historical Society, Academy of Natural Sciences, Engineers' Club, Franklin Institute, Library Co. of Philadelphia, Pennsylvania Hospital, Wagner Free Institute, Numismatic and Antiquarian Society, Profs. John Ashhurst, E. D. Cope, F. A. Genth, Henry D. Gregory, Lewis M. Haupt, James MacAlister, Benjamin Sharp, Drs. W. G. A. Bonwill, John H. Brinton, Edward A. Foggo, Persifor Frazer, George H. Horn, Frank W. Lewis, Morris Longstreth, John Marshall, George R. Morehouse, Charles A. Oliver, William Pepper, Charles Schäffer, Charles Stewart Wurts, Messrs. R. Meade Bache, Henry C. Baird, Cadwalader Biddle, George Tucker Bispham, Joel Cook, Jacob B. Eckfeldt, Charles C. Harrison, William A. Ingham, Benjamin Smith Lyman, Franklin Platt, J. Sergeant Price, Theodore D. Rand, J. G. Rosengarten, Julius F. Sachse, Coleman Sellers, F. D. Stone, W. P. Tatham, Joseph Willcox, Philadelphia; Mr. Heber S. Thompson, Pottsville, Pa.; Rev. F. A. Muhlenberg, Reading, Pa.; Dr. W. H. Appleton, Swarthmore, Pa.; Mr. Thomas S. Blair, Tyrone, Pa.; Philosophical Society, Mr. Philip P. Sharples, West Chester, Pa.; Agricultural Experiment Station, Newark, Del.; Maryland Institute for the Promotion of the Mechanic Arts, Enoch Pratt Free Library, Prof. Ira Remsen, Baltimore, Md.; University of Virginia, Charlottesville; West Virginia University, Morgantown; Georgia Historical Society, Savannah; Athenæum, Columbia, Tenn.; Newberry Library, Chicago, Ill.

Accessions to the Library were reported from the Comité de Conservation des Monuments de l' Art Arabe, Cairo, Egypt; Koloniaal Museum, Haarlem, Holland; Bataafsch Genootschap der Proefondervindelijke Wijsbegeerte, Rotterdam, Holland; Magyar Tudományos Akademia, Budapest, Hun-

gary; Württembergische Kommission für Landesgeschichte, Stuttgart; *Il Nuovo Cimento*, Pisa, Italy; Bibliothèque de la Faculté des Sciences, Marseilles, France; Prof. Gabriel de Mortillet, St. Germain-en-Laye, France; Mr. Charles Sedelmeyer, Paris, France; R. Academia de Ciencias y Artes, Barcelona, Spain; R. Academia de Ciencias, etc., Madrid, Spain; R. Meteorological Society, London, England; Mr. Robert Noxon Toppan, Cambridge, Mass.; General Alumni Society of University of Pennsylvania, College of Physicians, Profs. E. D. Cope, Theophilus Parvin, Philadelphia; Bureau of Education, Washington, D. C.; Western Society of Engineers, American Humane Association, Prof. Edmund J. James, Chicago, Ill.; Bishop Crescencio Carrillo, Merida, Yucatan; Instituto Médico Nacional, Mexico, Mex.; Agricultural Experiment Stations, Lake City, Fla., Fayettesville, Ark., Manhattan, Kans., Corvallis, Oreg., St. Anthony Park, Minn.

Mr. J. G. Rosengarten read an obituary notice of Rev. W. H. Furness, D.D.

Mrs. Stevenson read a paper on the recent discovery in Egypt of non-Egyptian remains. Numerous specimens were exhibited, principally pottery, showing various shapes of development. These belonged to a race which had invaded Egypt 3500 or 2800 B.C., bringing its customs without adopting much from the country occupied by it.

Dr. Frazer moved the thanks of the Society to Mrs. Stevenson for her address. Adopted.

Dr. Brinton objected to the identification of the Libyans with the neolithic tribes. In his view they were near relatives of the tribes now known as Berbers. In his opinion the invaders descended on Abydos from the Oasis Magna.

Pending nomination 1346 and new nomination 1347 were read.

Dr. Greene offered a resolution of inquiry, why certain omissions were made in the records of the proceedings.

The Secretaries explained that the communication was informal and without motion and seemed to have no place in the minutes.

On the resolution being put to vote, the yeas and nays being called, it was lost by 12 nays to 5 ayes.

Dr. Brinton offered the following:

Resolved, **That papers by non-members be read by title only, except when the author is present, or by unanimous consent of the Society.**

The resolution was referred by consent of mover to Council.

The rough minutes were read, and the Society adjourned.

APRIL 3 being Good Friday and a legal holiday, the meeting was postponed, by direction of the President, until April 10.

Stated Meeting, April 10, 1896.

Vice-President, Dr. PEPPER, in the Chair.

Present, 18 members.

Correspondence was submitted as follows:

Acknowledgments of election to membership from M. G. Bertin, Paris, France, March 15, 1896; Mr. Henry A. Pilsbry, Philadelphia, March 30, 1896.

Circular letter from the Principal and Vice-Chancellor of the University of Glasgow and the Lord Provost of Glasgow, on behalf of the Committee of Arrangements of Jubilee of the Right Hon. Prof. Lord Kelvin, on the completion of the fiftieth year of his tenure of the Chair of Natural Philosophy in the University of Glasgow, requesting the Society to appoint a representative to take part in the celebration, June 15 and 16, 1896.

An invitation, on parchment, from the University of Princeton, N. J., to attend its one hundred and fiftieth anniversary.

On motion, these letters were referred to the President, with power to appoint representatives.

Letters of envoy from the K. K. Astronomisch-Meteorologische Observatorium, Triest, Austria; K. Leopoldinisch-Carolinische Deutsche Akademie der Naturforscher, Halle a. S., Prussia; R. Accademia di Scienze, Lettere ed Arti,

Modena, Italy; Ministero di Pubblica Istruzione, Rome, Italy; Mr. James Douglas, New York, N.Y.; Field Columbian Museum, Chicago, Ill.; Museo de la Plata, Provincia de Buenos Aires, S. A.

Letters of acknowledgment from the Vogtländische Altertumsforschende Verein, Hohenleuben, Saxony (143, 146, 147); I. R. Accademia degli Agiati, Rovereto, Austria (142–147); K. Leopoldinisch-Carolinische Deutsche Akademie der Naturforscher, Halle a. S., Prussia (146, 147, and *Trans.*, xviii, 2); Academy of Science, Rochester, N. Y. (148); Prof. Charles A. Young, Princeton, N. J. (148); Mr. L. A. Scott, Philadelphia (148).

Letters of acknowledgment (149) from the Geological Survey, Ottawa, Canada; Manitoba Historical and Scientific Society, Winnipeg; Public Library, State Library, Boston, Mass.; Prof. C. H. Hitchcock, Hanover, N. H.; Prof. James Hall, Albany, N. Y.; Editor of *Popular Science Monthly*, Profs. C. F. Chandler, Isaac H. Hall, J. J. Stevenson, New York, N. Y.; Vassar Brothers' Institute, Poughkeepsie, N. Y.; Academy of Science, Geological Society of America, Rochester, N. Y.; Oneida Historical Society, Utica, N. Y.; New Jersey Historical Society, Newark; Prof. Charles A. Young, Princeton, N. J.; Prof. Martin H. Boyè, Coopersburg, Pa.; American Academy of Medicine, Prof. J. W. Moore, Easton, Pa.; State Library of Pennsylvania, Harrisburg; Hon. James T. Mitchell, Rev. H. Clay Trumbull, Drs. C. N. Peirce, Wm. H. Wahl, Messrs. Samuel Dickson, Patterson Du Bois, Philip C. Garrett, L. A. Scott, Frank Thomson, C. Tower, Jr., Philadelphia; Lackawanna Institute of History and Science, Scranton, Pa.; Weather Bureau, U. S. Naval Observatory, U. S. Geological Survey, U. S. Patent Office, Coast and Geodetic Survey, War Department, Dr. W. J. Hoffman, Prof. Chas. A. Schott, Washington, D. C.; Mr. T. L. Patterson, Cumberland, Md.; Mr. Jedediah Hotchkiss, Staunton, Va.; Elisha Mitchell Scientific Society, Chapel Hill, N. C.; South Carolina College, Columbia; University of Alabama, University P. O.; University of California, Prof. Joseph Le Conte, Berkeley, Cal.; Lick

Observatory, Mt. Hamilton, Cal.; Historical Society, State Mining Bureau, San Francisco, Cal.; Prof. J. C. Branner, Stanford University, Cal.; Geological Survey of Missouri, Jefferson City; Oberlin College, Oberlin, O.; Cincinnati Observatory, Cincinnati, O.; Prof. J. L. Campbell, Crawfordsville, Ind.; Prof. G. W. Hough, Evanston, Ill.; University Library, Champaign, Ill.; Dr. M. D. Ewell, Chicago, Ill.; Academy of Natural Sciences, Davenport, Ia.; State Historical Society of Iowa, Iowa City; University of Wisconsin, State Historical Society, Madison, Wis.; Kansas University *Quarterly*, Lawrence; Academy of Science, Washburn College Library, Topeka, Kans.; Colorado Scientific Society, Denver; Agricultural Experiment Stations—Geneva, N. Y.; Auburn, Ala.; Michigan Agricultural College, Ingham Co.; Ames, Ia.; Lincoln, Neb.; Corvallis, Oreg.; Tucson, Ariz.

Accessions to the Library were reported from the Geological Survey of India, Calcutta; Linnean Society of New South Wales, Sydney; Soc. Finno Ougrienne, Helsingfors, Finland; Ministerie van Binnenlandsche Zadun, s' Gravenhage, Netherlands; Osservatorio Astron. Meteorol., Triest, Austria; Akad. der Wissenschaften, R. Friedländer und Sohn, Berlin, Prussia; K. Leopold.-Carol. Akademie, Halle a. S., Prussia; Bayer. Numismat. Gesellschaft, München; R. Ministero della Instruzione Publica, Padova, Italia; R. Accad. di Scienze, etc., Modena, Italia; École Nat'l Supt. des Mines, Mr. Georges Bertin, Paris, France; Geographical Society, Manchester, Eng.; Canadian Institute, Ontario Archæological Museum, Mr. J. M. Clark, Toronto, Canada; Mr. George M. Whitaker, Boston, Mass.; Academy of Sciences, Amer. Museum Nat. History, Mr. James Douglas, New York, N. Y.; Free Public Library, Jersey City, N. J.; Lafayette College, Easton, Pa.; Pepper Laboratory of Clinical Medicine, Dr. Charles A. Oliver, Messrs. Wharton Barker, Frederick Prime, Maxwell Sommerville, Philadelphia; Lighthouse Board, U. S. Department of Agriculture, U. S. Geological Survey, Prof. Albert S. Gatschet, Washington, D. C.; University of California, Berkeley; State Historical Society, Madison, Wis.; State Historical Society,

Iowa City, Ia.; Agricultural Experiment Stations—College Park, Pa.; Lexington, Ky.; Columbia, Mo.; Agricultural College, Michigan; Madison, Wis.; Denver, Colo.; Berkeley, Cal.; Instituto Medico Nacional, Laminas, Mexico.

Photograph for the Society's Album was received from Dr. W. G. A. Bonwill, Philadelphia.

The following death was announced: Hon. William Strong, Washington, D. C., August 19, 1895.

A paper was read on the "Identification of Colored Inks by the Absorption Spectra," by Dr. C. A. Doremus, of New York.

Prof. Cope made some remarks on the figures of men and animals on a tablet from Nippur, and expressed the opinion that the men were of the pure white race and not mixed.

Dr. Brinton followed, corroborating the views of Prof. Cope.

Pending nominations 1346 and 1347, and new nominations 1348 to 1362, were read. On motion, the nominations of non-residents were referred to Council.

The Curators reported on the collections of coins and medals formerly deposited with the Numismatic Society, but at present deposited in the Pennsylvania Museum and School of Industrial Art. All the articles had been accounted for with but two exceptions.

The report was received, and the Curators discharged from further consideration of the subject.

The rough minutes were then read, and the Society adjourned.

The Identification of Colored Inks by their Absorption Spectra.

By Charles A. Doremus.

From the committee appointed by the Society to investigate the various methods for the examination of documents.

(Read before the American Philosophical Society, April 10, 1896.)

The substitution of aniline dyes for other coloring matters in the preparation of colored inks, especially red, necessitates the adoption of means for their recognition.

A characteristic feature of the aniline colors is a surface iridescence, distinguishable even in the thinnest layers.

The beetle bronze is unmistakable. The iridescence is frequently complementary to that of the color—thus green to red.

Many of these inks also show fluorescence. This is especially developed in very dilute solutions. Highly attenuated solutions of fluorescein behave differently to light from concentrated ones. The dichroism of concentrated solutions is quite distinct from the fluorescence obtained by dilution.

Concentration appears to destroy fluorescence. This is also true of glass. Glass containing ten per cent. of uranium oxide would not be recognized as the uranium glass whose greenish yellow fluorescence is so well known.

The writer was led to investigate many of these properties in connection with a case tried in New Jersey in 1891.* The circumstances were briefly as follows: Mr. George P. Gordon, of printing press fame, left a large estate by a will dated 1873. This will was rejected because the subscribing witnesses would not swear to the execution of it. The case became one of intestacy and was taken in charge by the Public Administrator of Brooklyn. The estate was then settled with the parties named in the will. The widow and a daughter by a first wife were the chief beneficiaries. The daughter died in 1890 and her will was offered for probate in New York city. A contest took place. The contesting attorneys received a letter from a party stating that he had seen a notice of the contest in the daily press and that they would hear something to their advantage should they communicate with him. This led to the finding (?) in a garret of a will purporting to have been executed by George P. Gordon in 1868. The subscribing witnesses to this document were all dead. The wife and daughter had also died before this alleged will was brought to light. This document was proved *ex parte* in New Jersey and ancillary probate was allowed in New York. The instrument was also filed in Trenton. The legal representatives of the heirs of the wife and daughter contested the genuineness of this will. The proponents were parties contesting the daughter's will to whom was joined Henry C. Adams, who claimed to have drawn the will and who would be benefited should it be established. For a time the litigation was conducted on the part of the contestants in attempts to prove by the handwriting that the signature of the testator was a forgery. The case to this point rested entirely upon expert testimony, when Adams brought forward a draft of the will purporting to have been made in July, 1868, and offered it in evidence. This draft was interlineated and amended with red ink. When submitted to expert chemists they pronounced the ink one of some aniline color and from general appearances eosine. The controversy then centred on the

*The Prerogative Court of the State of New Jersey in the matter of the Probate in solemn Form and the Last Will and Testament of George P. Gordon, deceased. *Jersey City News Press, 1891.*

question as to whether the ink was eosine or not. Experts were called for both sides and the writer was among those retained by the executors. As the right to use reagents on the document was denied all the preliminary tests had to be of a physical character, though they were afterwards verified by chemical tests in court. My attention had been called several years previously to the black appearance of the lips of players using rouge, one kind of which I knew to be eosine. Eosine is irresponsive to yellow rays and seems almost black in the glare of the footlights. Carmine and other reds retain more of their red color. Experiments were therefore made with different red inks, as carmine, aniline red, safranine, and eosine, and their appearance noted under monochromatic illumination of a sodium flame.

The results were not as pronounced as desired. Recourse was then had to comparing the various inks in strong daylight behind differently colored glasses. The effects were very striking, especially with the aniline inks since they possess iridescence.

Colored glasses also greatly aid in the discovery of their fluorescent qualities.

The ink on the document presented a lustre when illuminated through green glass which was quite different from that of carmine and various aniline inks.

The *fluorescence* of eosine may also be enhanced by the use of blue or purple glass.

These experiments induced the writer to try a spectroscopic examination of inks, both in solution and in form of writing.

A Zeiss micro-spectroscopic eye-piece and low-power lens were used at first, then a higher power. This test is especially valuable since the document is uninjured.

It requires the brightest sunlight as a source of illumination. The ink is viewed by transmitted light and an absorption spectrum is obtained. When mapped the spectra are found to vary.

This means of identification was, however, not sufficiently developed to enable it to be used in court, nor could it be shown because of the absence of proper facilities.

At court the preliminary examination of the experts was strengthened by chemical tests applied to the ink on the document and prominently the action of hydrochloric acid which produced a yellow color and by the greenish yellow fluorescent nature of a solution of the ink.

The opinion of the experts for the defense that the ink was eosine was corroborated by several ink manufacturers and a well-known importer of aniline dyes.

In rebuttal it was claimed that the ink was aurine.

It was necessary to break the evidence going to prove the ink to be eosine since that color was not discovered until 1874, eight years after the date of the will. Aurine was, however, in commercial use in 1865, and

as per patent of Henry Ellis, Great Britain, No. 2267. It was not shown, however, that it was purchasable as ink in this country in 1868.

The decision of the Chancellor in favor of the contestants was sustained in 1894 by the Court of Errors and Appeals.

While an alkaline aurine solution produces an ink very similar to eosine in many properties and reactions, it differs widely in others and especially in not having greenish yellow fluorescence of eosine in diluted solution and in not showing the same absorption spectrum and derivative spectra.

The accompanying maps show the spectra observed with thin layers of various inks. A Donné lactoscope proved very useful in varying the thickness of the layer until the most characteristic appearance was obtained. The same absorption bands were afterwards recognized when pen marks made with these inks were examined under a microscope to which a Zeiss spectroscopic eye-piece was adjusted.

The spectroscopic examination of the ink while on the document should be followed whenever allowed by observations of the spectra produced when the ink is subjected to the action of chemicals.

Very marked changes occur, and since even colorless solutions may show absorption bands this means of identification possesses the double advantage of an accurate physical test without injury to the document together with a combined chemical and physical test where the application of reagents is permitted.

Stated Meeting, April 17, 1896.

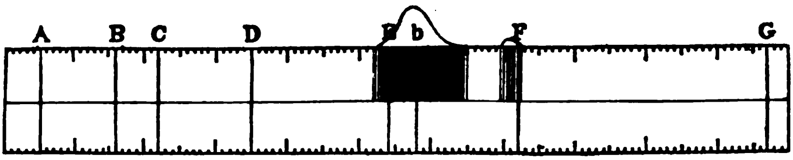
President, Mr. Fraley, in the Chair.

Present, 20 members.

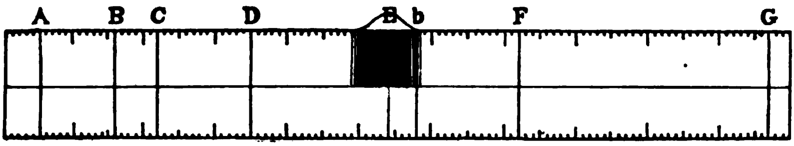
Mr. Georges Bertin, a newly elected member, was presented and took his seat.

Minutes of meeting of April 10 were read and approved.

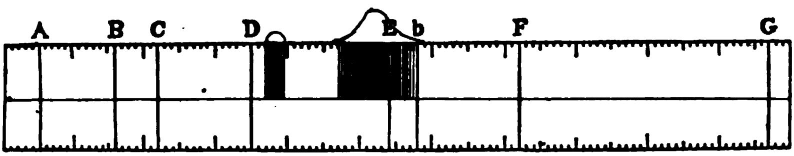
Letters of acknowledgment were received from the Public Library, Wellington, N. Z. (147); Universitatis Lundensis, Lund, Sweden (147); Profs. Friedrich Müller, Edward Suess, Vienna, Austria (148); Naturforschende Gesellschaft, Bamberg, Bavaria (147); K. Sächs. Meteorol. Institut, Chemnitz (148); Verein für Erdkunde, Dresden, Saxony (147, 148); Wetterauische Gesellschaft, Hanau, Germany (147); Verein für



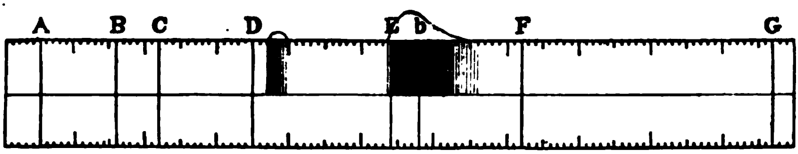
Eosine in Water.



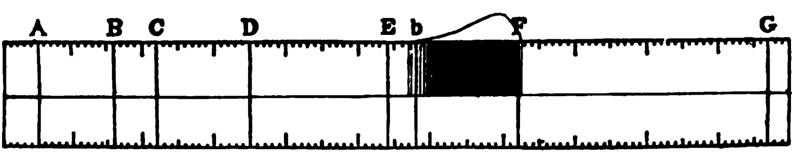
Aurine in Dilute Alkali.



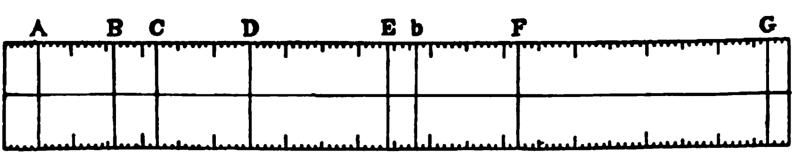
Carmine in Ammonium Hydrate.



David's Brilliant Carmine Ink.



Safranine.



Kunst und Alterthum, Ulm, Germany (143, 146, 147); R. Accademia di Scienze Lett. Arti, Modena, Italy (147); Texas Academy of Science, Austin (149); Kansas State Historical Society, Topeka (148); Observatorio Estado de Vera Cruz, Jalapa (144, 147, 149); Don Mariana Barcena, Observatorio Meteorologico, Mexico, Mex. (149).

Accessions to the Library were reported from the Genootschap van Kunsten en Wetenschappen, Batavia, Java; Nederlandsche Maatschappij ter bevordering, etc., Amsterdam, Netherlands; K. Universitetet, Lund, Sweden; Roemer Museum, Hildesheim, Prussia; Deutsche Geologische Gesellschaft, Berlin, Prussia; Académie des Sciences, Paris, France; Prof. Henry Wilde, Manchester, Eng.; Hon. J. M. LeMoine, Quebec, Canada; Amer. Antiquarian Society, Worcester, Mass.; Academy of Natural Sciences, Mr. A. E. Outerbridge, Philadelphia; U. S. Senate, U. S. Dep't of Agriculture, Washington, D. C.; California Academy of Sciences, San Francisco.

On behalf of the special committee in charge of the quarterly meetings, Dr. Pepper reported the details of that to occur May 1.

Dr. Brinton then read an obituary of the late Henry Hazlehurst.

Prof. Cope gave a brief account of his investigation of the remains found at Port Kennedy, the result so far being mammalia, 38; birds, 3; reptiles, 6.

In reply to Dr. Brinton, Prof Cope stated that the general term Plistocene is applied to the age of the deposit. It is part of Cenozoic times, beginning with a depression of probably 2200 feet, its middle corresponding with an elevation which had much to do with the preservation of the continental ice-cap. After this was a period of subsidence leaving but little land above the water.

In reply to Prof. Prime, Prof. Cope stated that Prof. Spencer had observed the depression along the New England coast.

Prof. Prime thought that no great depression could have

occurred in Pennsylvania, as the terminal moraine in Northampton county is but 650 feet above sea-level and is practically unchanged.

Pending nominations 1346 to 1362 were read.

The Library Committee reported through Dr. Greene and asked for an appropriation for the purchase of books and the filling of lacunæ.

On motion duly seconded the following was adopted:

Resolved, That an appropriation of $500 be made to the Committee on Library for expenses during the year 1896.

The rough minutes were read, and the Society adjourned.

Stated Meeting, May 1, 1896.

Vice-President, Dr. PEPPER, in the Chair.

Present, 39 members.

Correspondence was submitted.

The death of Jean Baptiste Léon Say, on April 21, was announced.

A letter was read by the Chairman from Dr. J. S. Minot, regretting his inability to be present and take part in the discussion.

A letter from the President announced that he had appointed Hon. Craig Biddle to represent this Society at the sesqui-centennial of Princeton University, and Dr. J. Cheston Morris at the semi-centennial jubilee of Lord Kelvin, at the University of Glasgow.

Prof. Cope was then called upon and opened the discussion of the "Factors of Organic Evolution," from the Palæontological standpoint.

Prof. Conklin followed, presenting the subject from an Embryological point of view.

Prof. L. D. Bailey, of Cornell, presented the subject from its Botanical aspect.

Dr. D. G. Brinton then presented his views of the subject.

The three original speakers were then called upon and each supplemented his remarks by thoughts suggested by the others.

In the course of his remarks, Prof. Cope exhibited two specimens illustrative of generalized types of Vertebrata. One of these was a cast of a species of the genus Phenacodus, from the Eocene, which represents the family from which all the Ungulate Placental Mammalia have descended. The other was a part of the skeleton of a reptile from the Permian, of the new genus Otocœlus. This genus is the type of a new family of the order Cotylosauria. This order approaches most nearly of all the Reptilia to the class Batrachia. It is also the most generalized of the Reptilia, and from it all other orders of the class have probably descended by modifications in different directions. The particular family Otocœlidæ differs from the other families of Cotylosauria in the possession of a meatus auditorius externus and of an osseous carapace. From it were probably descended the orders of Pseudosuchia and Testudinata, which first appear in the Trias. A description of this family and the species it includes will be given in an early number of the PROCEEDINGS of the Society.

Nominations 1346 to 1362 were read.

The Society was then adjourned.

The meeting of the first of May having been designated as that on which a discussion of the theme, "Factors of Organic Evolution," should be held, Prof. Cope, to whom the Special Committee in charge of the preparations for this meeting had confided the task of opening the discourse, presented an epitome of the subject as it exists to-day from the standpoint of paleontology.*

* [Prof. Cope, being unwilling to furnish the Society with the text of his remarks, or to have the stenographic copy printed in the PROCEEDINGS, his part of the joint discussion must be necessarily omitted.—SECRETARIES.]

Discussion of the Factors of Organic Evolution from the Embryological Standpoint.

By Prof. E. G. Conklin.

(Read before the American Philosophical Society, May 1, 1896.)

Up to the beginning of this decade embryology was largely dominated by the phylogeny idea. Individual development was generally studied, as the paleontologist studies his fossils, with a view to deciphering the evolutionary record in the various stages. It is now generally recognized, however, that embryology is but little fitted for the service into which it was so long forced, viz., the determining of phylogenies. The only safe guide in this matter is comparative anatomy of both living and extinct forms. On the other hand, our knowledge of the mechanics of evolution must always depend in large part upon the study of individual development. More than any other discipline, embryology holds the keys to the *method of evolution.* If ontogeny is not a true recapitulation it is, at least, a true *type* of evolution, and the study of the causes of development will go far to determine the factors of phylogeny.

The causes and methods of evolution are intimately bound up with those general phenomena of life such as assimilation, growth, differentiation, metabolism, inheritance, and variation; and the evolution problem can never be solved except through a study of these general phenomena of life itself. Our great need at present is not to know more of the course of evolution, but to discover, if possible, the causes of growth, differentiation, repetition, and variation. All these general phenomena are most beautifully illustrated in the development of individual organisms, and because they are fundamental to *any* theory of evolution I shall dwell upon them rather than upon the evidences for the Lamarckian or the Darwinian factors.

I call your attention very briefly to the following propositions: 1. Development, and consequently evolution, is the result of the interaction of extrinsic and intrinsic causes. 2. Intrinsic causes are dependent upon protoplasmic structure. 3. Inherited characters must be predetermined in the structure of the germinal protoplasm. 4. Germinal, as compared with somatic, protoplasm is relatively stable and continuous, but not absolutely so as maintained by Weismann; therefore, extrinsic causes may modify both germinal and somatic protoplasm. 5. It is extremely difficult to determine whether or not extrinsic factors have modified the structure of the germinal protoplasm. This is illustrated by some of the evidences advanced for the inherited effects of (1) diminished nutrition, (2) changes in environment, (3) use and disuse. 6. Experiment alone can furnish the crucial test of these Lamarckian factors.

1. The causes of development in general are usually recognized as twofold, extrinsic and intrinsic. As examples of extrinsic causes may be mentioned gravity, surface tension, light, heat, moisture, and chemism in general; examples of intrinsic causes are the non-exosmosis of salts from living bodies in water, the pouring of a glandular secretion or the sap of plants into a cavity under high pressure, the active changes in shape and position on the part of cells, assimilation, growth, division, etc. There is not, however, a uniformly sharp and distinct line of demarcation between these two factors of development. Phenomena once supposed to be due entirely to intrinsic causes are now known to be the result of extrinsic ones, and it is practically certain that this will be found true of still other phenomena. But although it is not possible to draw any hard and fast line between these two classes of causes, one can, in general, recognize a very marked difference between them. Extrinsic causes may, in large part, supply the stimulus and the energy for development, and may more or less modify its course; the intrinsic causes are of a much more complex character than the extrinsic ones, they are inherent in the living matter and in large part predetermine the course of development. In one form or another the distinction between these two classes of causes is recognized by all naturalists. His calls the intrinsic causes "the law of growth," the extrinsic ones the conditions under which that law operates. These designations correspond, at least in part, to Prof. Cope's Anagenesis and Katagenesis, and to Roux's "simple and complex components" of developmental processes.

While it is necessary to emphasize the differences between these two classes of causes, it is not intended thereby to dogmatically assert their total difference in kind. It may well be that these extrinsic and intrinsic causes are totally different in kind, but in our present state of ignorance it would be unjustifiable to affirm it. On the other hand, it would be just as unwarrantable to dogmatically affirm that there is no difference in kind between these two classes of causes, and that, therefore, all vital phenomena are only the manifestations of heat, light, electricity, attraction, repulsion, chemism, and the like. It may be that this is true, but there is as yet no sufficient evidence for it, and to attempt, as certain dynamical and mechanical hypotheses do, to refer all vital phenomena directly to such simple components as those named above is practically to make impossible at present any explanation of vital phenomena. "If we would advance without interruption," says Roux,* "we must be content, for many years to come, with an analysis into complex components."

2. We need not now further concern ourselves with an explanation of *extrinsic* causes or *simple* components, since this subject properly belongs to chemistry and physics. If, however, we examine more closely some of the *intrinsic* causes or *complex* components, we will find

* Wilhelm Roux, *Einleitung. Archiv für Entwicklungsmechanik der Organismen.*

that they are always associated with more or less complex ***structures; in fact, that they are dependent upon structure.***

The smallest and simplest mass of protoplasm that can manifest all the fundamental phenomena of life, such as assimilation, growth, division, and metabolism, is an entire cell, nucleus and cytoplasm, and probably centrosome. The cell is composed, as microscopic study plainly reveals, of many dissimilar but perfectly coadapted parts, each performing its specific function, and it may therefore properly be called an ***organism.*** Some phenomena of cell life may be directly referred to the various visible constituents of the cell, but many of them are evidently connected with structures which we cannot see, structures which may perhaps never be seen, and yet which must be vastly more complex than the most complex molecules known to chemistry, and yet much more simple than the microsomes, centrosomes, and chromosomes which are visible in the cell. With these ultra-microscopical particles many of the most fundamental phenomena of life are associated, viz., assimilation, growth, metabolism, and probably differentiation, repetition, and variation. These functions are so coördinated that there can be no question that the ultra-microscopical structure is an ***organization,*** with part coadapted to part. The organization of the cell, therefore, does not stop with what the microscope reveals, but must be supposed to extend to the smallest ultimate particles of living matter which manifest specific functions. These are the vital units so generally postulated, the "smallest parts" of living matter, as they were called by Brücke, who first demonstrated that they must exist; the "physiological units" of Spencer, the "gemmules" of Darwin, the "micella-groups" of Nageli, the "pangenes" of De Vries, the "plasomes" of Wiesner, the "idioblasts" of Hertwig, the "biophores" of Weismann. Such ultimate units have been found absolutely necessary to explain those most fundamental of all vital phenomena, ***assimilation*** and ***growth,*** while many other phenomena, especially ***particulate inheritance,*** the ***independent variability of parts,*** and the hereditary transmission of ***latent*** and ***patent characters,*** can at present only be explained by referring them to ultra-microscopical units of structure. To deny that there are such units does not simplify the problem, as some seem to suppose, but renders it impossible of approach. A corpuscular hypothesis of life, like that of light, may be only a temporary makeshift, but it is better than nothing.

Whitman* well says: "Brücke's great merit consists in this that he taught us the necessity of assuming structure as the basis of vital phenomena, in spite of the negative testimony of our imperfect microscopes. That function presupposes structure is now an accepted axiom, and we need only extend Brücke's method of reasoning, from the tissue cell to the egg cell, in order to see that there is no escape from the

* C. O. Whitman, *The Inadequacy of the Cell-Theory of Development*, Biological Lectures. 1893.

conclusion that the whole course of developmental phenomena must be referred to organization of some sort. Development, no less than other vital phenomena, is a function of organization."

3. A study of the phenomena of development, as well as the principle of causality, make it certain that all the characters of the species are predetermined within the protoplasm of the fertilized egg cell. From a frog's egg only a frog will develop, from an echinoderm egg only an echinoderm, and the course of the development is, under normal circumstances, definitely marked out in each case, even down to the minutest details. All the results of experiment, as well as observation and induction, only serve to render this conclusion the more certain. It should be observed that to affirm that characters are predetermined is a very different thing from saying they are preformed. The one merely asserts that the cause of the transformations which lead from one step to another in the development is determined by the initial conditions of the fertilized egg cell; the other affirms that those transformations have already taken place.

The absolute determinism of development depends primarily upon the constant structure of the egg cell, but also to a certain extent upon a definite relation to extrinsic factors. Since, however, these extrinsic factors may be exactly the same in two cases, and yet the result of development be very different (*e. g.*, the egg of the starfish and that of the sea urchin), we can only conclude that while ontogenetic differences may be caused by a disturbance of the extrinsic factors, *inherited characters* are always the result of a definite structure of the germinal protoplasm, and that, therefore, development is, in the words of Prof. Whitman, "a function of organization."

Inheritance and variation are general terms which include a great many different kinds of phenomena, many of which seem to be due to entirely different factors. A great many phenomena of inheritance seem to be due entirely to extrinsic forces, but a more careful inquiry always reveals the fact that they are invariably due to the reaction of certain extrinsic causes on a perfectly definite living structure. As examples may be mentioned the following:

(1) The tiger-like striping of the egg of Fundulus, which is very characteristic and would certainly be regarded as an inherited character, has been shown by Loeb* to be due entirely to the position of the blood vessels of the blastoderm. The pigment cells are at first uniformly distributed, but when the blood vessels are formed they gather around them, probably through chemotropic action, and thus the characteristic banded appearance is produced. Graf has since shown that the color paterns of leaches are produced in the same way. It is not necessary, therefore, to assume that the color paterns in these cases are specifically represented in the germinal protoplasm; it may

*Jacques Loeb, *Some Facts and Principles of Physiological Morphology*, Biological Lectures, 1893.

even be that the position of the blood vessels is not so represented, but there must be some ultimate cause back in the germinal plasm itself which determines the series of causes which finally produces the color paterns. In short, this feature, like most others, was predetermined from the beginning.

(2) Herbst* has shown in a series of interesting experiments that by the use of various chemical substances the development of echinoderms may be profoundly modified. For example, in sea water deficient in calcium-chloride, or in which there is an excess of potassium-chloride, the pluteus larva, instead of developing calcareous spicules and the long ciliated arms which give the normal larva an angular, easel-shaped appearance, remains rounded in shape much like the larva of Balanoglossus, in which no spicular skeleton is developed. The withdrawal, therefore, of certain normally present substances from the environment may profoundly modify the end result. But in this case, as in the other, it is absolutely certain that the calcareous spicules were predetermined in the egg cell, although in the absence of calcareous matter from the water those spicules could not be built—the plan was there, but the building material was lacking.

Such modifications resulting from unusual conditions of pressure, temperature, density, nutrition—in fact, any alteration of the chemical or physical environment—may appear in any stage of development from the unsegmented egg to the adult condition, but it must not be supposed that the entire development can be reduced to such factors. Loeb argues that we do not inherit our body heat from our parents because it depends upon certain chemical processes, but is it not absolutely certain that we inherit a certain protoplasmic structure which determines those chemical processes, and hence the body temperature? To assume that extrinsic causes determine whether there shall hatch from an egg a chicken or an eagle is the sheerest nonsense. The study of extrinsic factors in relation to inheritance will serve to simplify some of the intricate problems to be explained, but surely no one believes that development can ever be referred entirely to such factors. The fact is that determinism, which is the most fundamental characteristic of inheritance, is manifested at every step of development, and there is certainly no escape from the conclusion that this determinism depends upon protoplasmic structure, and that this structure it is which is transmitted from generation to generation and which forms the physical basis of inheritance.

All really inherited characters must, therefore, be represented in the structure of the germinal protoplasm, and must consequently be present from the beginning of development. "We must consider it as a law derivable from the causality principle," says Hatschek,† "that in

*_Zeit. wiss. Zool._, Bd. lv.

† Berthold Hatschek, _Ueber die Entwicklungsgeschichte von Teredo_, Arb. Zool. Inst., Wien, 1880.

the phylogenetic alterations of an animal form the end stages are not alone altered, but the entire series from the egg cell to the end stage. Every alteration of an end stage or addition of a new one must be caused by an alteration of the egg cell itself." Nägeli * has expressed a similar view in the following famous sentence: "Egg cells must contain all the essential characteristics of the species as perfectly as do adult organisms, and hence they must differ from one another, no less as egg cells than in the fully developed state. The species is contained in the egg of the hen as completely as in the hen, and the hen's egg differs as much from the frog's egg as the hen from the frog."

4. The remarkable tenacity of inheritance, as shown especially in reversions and the preservation of useless and embryonic characters through many hundreds or thousands of generations, and amid the most diverse circumstances, bears strong testimony to the great stability of that living structure which is the basis of inheritance. On the other hand, all experience goes to prove that the living substance of the body cells in general is readily modified, and that in a surprisingly short time. The fact of this great difference cannot fail to be recognized; its cause is at present merely a matter of conjecture.

Weismann at one time supposed the cause of this to be an absolutely stable, absolutely separate, and perpetually continuous germ plasm. However, there is the most convincing and abundant evidence that although the germ plasm is relatively very stable and continuous, it does not possess those divinely perfect characters ascribed to it. More recently Weismann has expressly abandoned each and all of these characters,† and now, like a good Lamarckian, finds "the cause of hereditary variation in the direct effects of external influences on the biophores and determinants."

The outcome of the whole matter, then, is that we find ourselves much in the same position as we were before Weismann denied the possibility of the inheritance of acquired characters. *All hereditary variations are caused by the action of extrinsic forces on the germinal protoplasm, producing changes in its structure.* Strangely enough, this proposition was admitted as a logical necessity by one who undertook by rigorous logic to prove the reverse. Since almost the only objection to this position was the one raised by Weismann, it may now be considered as definitely settled, and the only question before us, then, is: How can extrinsic causes modify the structure of the germinal protoplasm?

Since by his own admissions, as Romanes has shown, the most characteristic features of Weismann's system, both as to inheritance and evolution, have been virtually abandoned, it seems to some that his theories have been of no real value, and that, like an *ignis fatuus*, they have only served to lead biologists astray far from the path of science into the dangerous quagmires of speculation. I do not share any such

* Nägeli, *Mechanisch-physiologische Theorie der Abstammungslehre*, 1884.
† See Romanes' *Examination of Weismannism*, 1893.

opinion. Apart from his splendid observations and the great stimulus to investigation which Weismann's theories have furnished, there remain many elements of permanent value in his work.

Osborn * thinks that Weismann's most "permanent service to biology is his demand for direct evidence of the Lamarckian principle." It seems to me that his greatest service consists in the emphasis which he has laid upon the intrinsic factors of development and evolution as opposed to the extrinsic factors, a thing which he has indeed over-emphasized, but which has sadly needed a strong defender in these later years. Largely as an outcome of his work, we now recognize the possibilities and the limitations of the selection theory as never before, and we also recognize that many of the evidences which were adduced in support of the Lamarckian factors are not conclusive, while the method of securing conclusive evidence is clearly marked out. Whatever we may think of his theories, this certainly is no slight service.

5. It is by no means an easy task to determine whether the influence of extrinsic forces has really reached the germinal protoplasm and modified its structure; much more difficult is it to determine how that modification takes place. I believe it is safe to say that a majority of the cases which are supposed to prove the inheritance of acquired characters prove only that characters are acquired, not that they are inherited. There is great need of caution against supposing that any character is inherited unless it repeats itself under many and different conditions. Apart altogether from inheritance, similar conditions may produce similar results, and consequently this source of error must be eliminated if we would be certain that the structure of the germinal protoplasm has really been modified. Many of the alleged cases of the inheritance of mutilations, ot the direct influence of the environment and of use and disuse fall away under this precaution.

The general evidence for the inheritance of mutilations is so notoriously bad that I pass it by altogether, and select for consideration a few cases, chosen from a recent work on the subject,† which have by various writers been alleged as showing the direct influence of environment in modifying species and also the inherited effects of use and disuse.

(1) It is well known that certain gasteropods, if reared in small vessels, are smaller than when grown in large ones, and this case has been cited as showing the influence of environment in modifying species. There is good evidence, however, that this modification does not affect the germinal protoplasm, for these same gasteropods will grow larger if placed in larger vessels. It seems very probable that the diminished size of these animals is due to deficient food supply, but this has so little modified the somatic protoplasm that, although they may be fully developed as shown by sexual maturity, they at once

* Osborn, *The Unknown Factors of Evolution*, Biological Lectures, 1894.

† E. D. Cope, *The Primary Factors of Organic Evolution*, 1896.

increase in size as soon as more abundant food is provided, and this takes place by the active growth and division of all the cells of the body. In higher animals, once maturity has been reached, there is little chance for growth, apparently because many of the cells are so highly differentiated that they can no longer divide. Consequently the growth is limited, and hence the size of the adult may depend in part upon the amount of nutriment furnished to the embryo. This limitation of growth is due to the high degree of differentiation of the somatic cells. But as the germ cells are not highly differentiated and are capable of division, it follows that they would not be permanently modified by starving. It may be, as Prof. Brewer argues, that long continued starving and consequent dwarfing of animals may leave its mark on the germinal plasm; but, as he also remarks, this influence must be very slight as compared with the cumulative effects of selection in breeding, and it is safe to assert that there is no such wholesale and immediate modification of the germinal plasm due to the influence of nutrition as some people seem to suppose.

(2) The interesting experiments of Schmankewitsch in transforming one species of Artemia into another by gradually increasing the salinity of the water, or in transforming Artemia into another genus, Branchinecta, by decreasing the salinity of the water are well known, and are often cited as illustrations of the fact that specific and even generic differences may suddenly be produced under the influence of the environment. The very fact, however, that these changes are suddenly produced, and that they can at will be quickly modified in one direction or the other is evidence that they are not represented in the structure of the germinal plasm, and the fact that definite extrinsic causes, such as salt or fresh water, acting upon this plasm produces results which are constantly the same is the best evidence that the internal mechanism, *i. e.*, the structure of the germinal plasm, is constantly the same. The same can be said of many artificially produced modifications, such as the exogastrulas and potassium larvæ of Herbst, all of which profound changes are due entirely to extrinsic and not to intrinsic causes, as is shown by the fact that they disappear as soon as the immediate extrinsic cause is withdrawn. The same thing is shown in Poulton's experiments on the colors of Lepidopterous larvæ, and in this case also it is known that the changes are not inherited, at least during the limited period through which the experiments were conducted; and it should be observed that to assume that this would take place at the end of an indefinite number of generations is simply to beg the question.

Very many other cases of a similar character might be instanced under this head if time permitted, but I hasten on to another class of evidence.

Under the subject of the inherited effects of use and disuse the following cases may be mentioned as showing how inconclusive much of this evidence is:

(1) In the first place, this whole line of argument starts with the assumption that the individual habits of an animal are inherited, and that these habits ultimately determine the structure—an assumption which really begs the whole question; for, after all, the substratum of any habit must be some physical structure, and if modified habits are inherited it must be because some modified structure is inherited. I take an example which will serve as an illustration of a whole class: Jackson* says that the elongated siphon of Mya, the long-necked clam, is due to its habit of burrowing in the mud, or to quote his words: "It seems very evident that the long siphon of this genus was brought about by the effort to reach the surface, induced by the habit of deep burial." It certainly would be pertinent to inquire where it got this habit, and how it happened to be transmitted. It is surely as difficult to explain the acquisition and inheritance of habits, the basis of which we do not know, as it is to explain the acquisition and inheritance of structures which are tangible and visible. Such a method of procedure, in addition to begging the whole question, commits the further sin of reasoning from the relatively unknown to the relatively known!

This case is but a fair sample of a whole class, among which may be mentioned the following: The derivation of the long hind legs of jumping animals, the long fore legs of climbing animals, and the elongation of all the legs of running animals through the influence of an inherited habit. All such cases are open to the very serious objection mentioned above.

(2) Another whole class of arguments may be reduced to this proposition: Because necessary mechanical conditions are never violated by organisms, therefore modifications due to such conditions show the inheritance of acquired characters. Plainly, the alternative proposition is this: If acquired characters are not inherited, organisms ought to do impossible things.

(3) Many of the arguments advanced to prove the inheritance of characters acquired through use or disuse seem to me to prove entirely too much. For example, Prof. Cope argues very ably that bones are lengthened by both stretch and impact, and that modifications thus produced are inherited. Even granting that this is true, how would it be possible for this process of lengthening to cease, since in active animals the stretch and impact must be continual? Prof. Cope answers that the growth ceases when "equilibrium" is reached. I confess I cannot understand this explanation, since the assumed stimulus to growth must be continual. But granting again that growth may stop when an animal's legs become long enough to "satisfy its needs," how on this principle are we to account for the *shortening* of legs, as, for example, in the turnspit dog and the ancon sheep and numberless cases occurring in nature? If any one species was able, by taking thought of mechanical stresses and strains, to add one cubit unto its stature, how could the same stresses and strains be invoked to decrease its stature?

* R. T. Jackson, *Memoirs Boston Soc. Nat. Hist.*, 1890.

These evidences are, I know, not the strongest ones which can be adduced in support of the Lamarckian factors. There are at present a relatively small number of such arguments which seem to be valid and the great force of which I fully admit. But the cases which I have cited are, I believe, fair samples of the majority of the evidences so far presented, and in the face of such "evidence" it is not surprising that one who is himself a profound student of the subject and a convinced Lamarckian prays that the Lamarckian theory may be delivered from its friends.*

6. Another line of evidence, and by far the most promising, is that of direct experiment. So far most of the experiments which have been carried on to determine this question have been carried only half way to a conclusion—they have shown that characters are acquired, they have usually failed to show that they are transmitted to descendants. Among animals one of the best known cases is the inheritance of epilepsy and other disorders in Guinea pigs, due to certain nervous lesions of the parents. But Romanes,† who spent much time in trying to corroborate these results, concludes as follows: "On the whole, then, as regards Brown-Sequard's experiments, it will be seen that I have not been able to furnish any approach to a full corroboration."

Among plants, on the other hand, there is more and better experimental evidence, but it is not by any means as full or satisfactory as could be wished. Of one thing we may be certain: a satisfactory solution of the problem can be reached only by experiment. The mere observations and inductions of the morphologist, while affording valuable collateral evidence, can never furnish the crucial test. As long as we deal merely with probabilities of a low order there will be profound differences of opinion: *e. g.*, Cope believes in all the Lamarckian factors; Romanes rejects use and disuse, but believes in the others; Weismann rejects all of them. Why? Is it because each does not know the facts upon which the others build? Certainly not. Those so-called facts are merely probabilities of a higher or lower order, and to one man they seem more important than to another. No conviction based even upon a high degree of probability can ever be reached in this way. There is here a deadlock of opinion, each challenging the other to produce indubitable proof. This can never be furnished by observation alone. Possibly even experiment may fail in it, but at least it is the only hope.

Conclusion.

On the whole, then, I believe the facts which are at present at our disposal justify a return to the position of Darwin. Neither Weismannism nor Lamarckism alone can explain the causes of evolution. But Darwinism can explain those causes. Darwin endeavored to show that

* H. F. Osborn, *Evolution and Heredity*, Biological Lectures, 1890.

† G. J. Romanes, *Post-Darwinian Questions*, 1895.

variations, perhaps even adaptations, were the result of extrinsic factors acting upon the organism, and that these variations or adaptations were increased and improved by natural selection. This is, I believe, the only ground which is at present tenable, and it is but another testimony to the greatness of that man of men, that, after exploring for a score of years all the ins and outs of pure selection and pure adaptation, men are now coming back to the position outlined and unswervingly maintained by him.

Finally, we ought not to suppose that we have already reached a satisfactory solution of the evolution problem, or are, indeed, near such a solution. "We must not conceal from ourselves the fact," says Roux, "that the causal investigation of organism is one of the most difficult, if not the most difficult, problem which the human intellect has attempted to solve, and that this investigation, like every causal science, can never reach completeness, since every new cause ascertained only gives rise to fresh questions concerning the cause of this cause."

The Factors of Organic Evolution from a Botanical Standpoint.

By Prof. L. H. Bailey.

(Read before the American Philosophical Society, May 1, 1896.)

THE SURVIVAL OF THE UNLIKE.

We all agree that there has been and is evolution; but we probably all disagree as to the exact agencies and forces which have been and are responsible for it. The subject of the agencies and vehicles of evolution has been gone over repeatedly and carefully for the animal creation, but there is comparatively little similar research and speculation for the plant creation. This deficiency upon the plant side is my excuse for calling your attention, in a popular way, to a few suggestions respecting the continuing creation of the vegetable world, and to a somewhat discursive consideration of a number of illustrations of the methods of advance of plant types.

1. *Nature of the Divergence of the Plant and Animal.*

It is self-evident that the development of life upon our planet has taken place along two divergent lines. These lines originated at a common point. This common life-plasma was probably at first more animal-like than plant-like. The stage in which this life-plasma first began to assume plant-like functions is closely and possibly exactly preserved to us in that great class of organisms which are known as mycetozoa when studied by zoölogists and as myxomycetes when studied by botanists. At one stage

of their existence, these organisms are amœba-like, that is, animal-like, but at another stage they are sporiferous or plant like. The initial divergencies in organisms were no doubt concerned chiefly in the methods of appropriating food, the animal-like organisms apprehending their food at a more or less definite point, and the plant-like organisms absorbing food throughout the greater or even the entire part of their periphery. It is not my purpose to trace the particular steps or methods of these divergencies, but to call your attention to what I believe to be a fundamental distinction between the two lines of development, and one which I do not remember to have seen stated in the exact form in which it lies in my mind.

Both lines probably started out with a more or less well-marked circular arrangement of the parts or organs. This was consequent upon the peripheral arrangement of the new cells in the development of the multicellular organism from the unicellular one. A long line of animal life developed in obedience to this peripheral or rotate type of organization, ending in the echinoderms and some of the mollusks. This line long ago reached its zenith. No line of descent can be traced from them, according to Cope. The progressive and regnant type of animal life appeared in the vermes or true worms, forms which are characterized by a two-sided or bilateral, and therefore more or less longitudinal, structure. The animal-like organisms were strongly developed in the power of locomotion, and it is easy to see that the rotate or centrifugal construction would place the organism at a comparative disadvantage, because its seat of sensation is farthest removed from the external stimuli. But the worm-like organisms, "being longitudinal and bilateral," writes Cope, "one extremity becomes differentiated by first contact with the environment." In other words, the animal type has shown a cephalic, or head-forming, evolution in consequence of the bilateralism of structure. The individual has become concentrated. Out of this worm-form type, therefore, all the higher ranges of zoötypic evolution have sprung, and one is almost tempted to read a literal truth into David's lamentation that "I am a worm and no man."

If, now, we turn to plants we find the rotate or peripheral arrangement of parts emphasized in all the higher ranges of forms. The most marked bilateralism in the plant world is amongst the bacteria, desmids, and the like, in which locomotion is markedly developed; and these are also amongst the lowest plant types. But plants soon became attached to the earth, or, as Cope terms them, they are "earth parasites." They therefore found it to their advantage to reach out in every direction from their support in the search for food. Whilst the centrifugal arrangement has strongly tended to disappear in the animal creation, it has tended with equal strength to persist and to augment itself in the plant creation. Its marked development amongst plants began with the acquirement of terrestrial life, and with the consequent evolution of the asexual or sporophytic type of vegetation. Normally, the higher type of plant bears its

parts more or less equally upon all sides, and the limit to growth is still determined by the immediate environment of the given individual or of its recent ancestors. Its evolution has been acephalic, diffuse, or headless, and the individual plant or tree has no proper concentration of parts. For the most part, it is filled with unspecialized plasma, which, when removed from the parent individual (as in cuttings and grafts), is able to reproduce another like individual. The arrangements of leaves, branches, the parts of the flower, and even of seeds in the fruit, are thus rotate or circular, and in the highest type of plants the annual lateral increments of growth are disposed in like fashion; and it is significant to observe that in the compositæ, which is considered to be the latest and highest general type of plant-form, the rotate or centrifugal arrangement is most emphatically developed. The circular arrangement of parts is the typical one for higher plants, and any departure from this form is a specialization and demands explanation.

The point I wish to urge, therefore, is the nature of the obvious or external divergence of plant-like and animal-like lines of ascent. The significance of the bilateral structure of animal-types is well understood, but this significance has been drawn, so far as I know, from a comparison of bilateral or dimeric animals with rotate or polymeric animals. I want to put a larger meaning into it, by making bilateralism the symbol of the onward march of animal evolution and circumlateralism (if I may invent the term) the symbol of plant evolution. The suggestion, however, applies simply to the general arrangement of the parts or organs of the plant body, and has no relation whatever to functional attributes or processes. It is a suggestion of analogues, not of homologues. We may, therefore, contrast these two great lines of ascent, which, with so many vicissitudes, have come up through the ages, as Dipleurogenesis and Centrogenesis.

The two divergent directions of the lines or phyla of evolution have often been the subject of comment, but one of the sharpest contrasts between the two was made in 1884 by Cope, when he proposed that the vegetable kingdom has undergone a degenerate or retrogressive evolution. "The plants in general," he then wrote, "in the persons of their protist ancestors, soon left a free-swimming life and became sessile. Their lives thus became parasitic, more automatic, and, in one sense, degenerate." The evolution of the plant creation is, therefore, held to be a phenomenon of catagenesis or decadence. This, of course, is merely a method of stating a comparison with the evolution of the animal line or phylum, and is therefore of the greatest service. For myself, however, I dislike the terms retrogressive, catagenetic, and the like, as applied to the plant creation, because they imply intrinsic or actual degeneracy. True retrogressive or degenerate evolution is the result of loss of attributes. Cope holds that the chief proof of degeneracy in the plant world is the loss of a free-swimming habit, but it is possible that the first life-plasma was stationary; at any rate, we do not know that it was motile. Degen-

eracy is unequivocally seen in certain restricted groups where the loss of characters can be traced directly to adaptive changes, as in the loss of limbs in the serpents. Retarded evolution expresses the development of the plant world better than the above terms, but even this is erroneous because plant types exhibit quite as complete an adaptation to an enormous variety of conditions as animals do, and there has been rapid progress towards specialization of structure. As a matter of fact, the vegetable world does not exhibit, as a whole, any backward step, any loss of characters once gained, nor any stationary or retarded periods; but its progress has been widely unlike that of the animal world and it has not reached the heights which that line of ascent has attained. The plant phylum cannot be said to be catagenetic, but suigenetic. Or, in other words, it is centrogenetic as distinguished from dipleurogenetic.

The hearer should be reminded, at this point, of the curious alternation of generations which has come about in the plant world. One generation develops sexual functions, and the product of the sexual union is an asexual generation, and this, in turn, gives rise to another sexual generation like the first. In the lowest sex-plants, as the algæ, the sexual generation—or the gametophyte, as it is called—generally comprises the entire plant body, and the asexual generation—or sporophyte—develops as a part of the fructifying structure of the gametophyte, and is recognizable as a separate structure only by students of special training. In the fungi, which are probably of catagenetic evolution, alternation of generations is very imperfect or wanting. In the true mosses, the gametophyte is still the conspicuous part of the plant structure. It comprises all that part of the moss which the casual observer recognizes as "the plant." The sporophytic generation is still attached to the persistent gametophyte, and it is the capsule with its stem and appendages. In the ferns, however, the gametophytic stage is of short duration. It is the inconspicuous prothallus, which follows the germination of the spore. Therefrom originates "the fern," all of which is sporophytic, and the gametophyte perishes. With the evolution of the flowering plants, the gametophyte becomes still more rudimentary, whilst the sporophyte is the plant, tree or bush, as we see it. The gametophytic generation is associated with the act of fertilization, the male prothallus or gametophyte developing from the pollen grain and soon perishing, and the female prothallus or gametophyte developing in the ovule and either soon perishing or persisting in the form of the albumen of the seed. The great development of the sporophyte in later time is no doubt a consequence of the necessity of assuming a terrestrial life; and with this development has come the perfection of the centrogenic form.

2. *The Origin of Differences.*

The causes which have contributed to the origin of the differences which we see in the organic creation have been and still are the subjects of the

most violent controversy. Those persons who conceive these differences to have come into existence full-formed, as they exist at the present time, are those who believe in the dogma of special creations, and they usually add to the doctrine a belief in design in nature. This doctrine of special creation receives its strongest support when persons contrast individual objects in nature. Certainly nothing can seem more unlike in very fundamental character than an insect and an elephant, a star-fish and a potato, a man and an oak tree. The moment one comes to study the genealogies of these subjects or groups, however, he comes upon the astonishing fact that the ancestors are more and more alike the farther back they are traced. In other words, there are great series of convergent histories. Every naturalist, therefore, is compelled to admit that differences in nature have somehow been augmented in the long processes of time. It is unnecessary, therefore, that he seek the causes of present differences until he shall have determined the causes of the smallest or original differences. It is thus seen that there are two great and coördinate problems in the study of evolution, the causes of initial differences, and the means by which differences are augmented. These two problems are no doubt very often expressions of the same force or power, for the augmentation of a difference comes about by the origination of new degrees of difference, that is, by new differences. It is very probable that the original genesis of the differences is often due to the operation of the very same physiological processes which gradually enlarge the difference into a gulf of wide separation.

In approaching this question of the origin of unlikenesses, the inquirer must first divest himself of the effects of all previous teaching and thinking. We have reason to assume that all beings came from one original life-plasma, and we must assume that this plasma had the power of perpetuating its physiological identity. Most persons still further assume that this plasma must have been endowed with the property of reproducing all its characters of form and habit exactly, but such assumption is wholly gratuitous and is born of the age-long habit of thinking that like produces like. We really have no right to assume either that this plasma was or was not constituted with the power of exact reproduction of all its attributes, unless the behavior of its ascendants forces us to the one or the other conclusion. Inasmuch as no two individual organisms ever are or ever have been exactly alike, so far as we can determine, it seems to me to be the logical necessity to assume that like never did and never can produce like. The closer we are able to approach to plasmodial and unspecialized forms of life in our studies of organisms, the more are we impressed with the weakness of the hereditary power. Every tyro in the study of protoplasm knows that the amœba has no form. The shapes which it assumes are individual, and do not pass to the descendants. To my mind, therefore, it is a more violent assumption to suppose that this first unspecialized plasma should exactly reproduce all its minor features than to suppose that it had no distinct hereditary power and therefore, by

the very nature of its constitution, could not exactly reproduce itself. The burden of proof has been thrown upon those who attempt to explain the initial origin of differences, but it should really be thrown upon those who assume that life-matter was originally so constructed as to rigidly recast itself into one mould in each succeeding generation. I see less reason for dogmatically assuming that like produces like than I do for supposing that unlike produces unlike.

I advanced this proposition a year ago in my *Plant-Breeding* (pp, 9, 10), and I am now glad to find, since writing the above paragraph, that H. S. Williams has reached similar conclusions in his new *Geological Biology.* He regards mutability as the fundamental law of organisms, and speaks of the prevalent notion that organisms must necessarily reproduce themselves exactly as "one of the chief inconsistencies in the prevalent conception of the nature of organisms." "While the doctrine of mutability of species has generally taken the place of immutability," he writes, "the proposition that like produces like in organic generation is still generally, and I suppose almost universally, accepted. It therefore becomes necessary to suppose that variation is exceptional, and that some reason for the accumulation of variation is necessary to account for the great divergencies seen in different species. . . . . The search has been for some cause of the variation : it is more probable that mutability is the normal law of organic action, and that permanency is the acquired law." I do not suppose that Professor Williams makes definite variation an inherent or necessary quality of organic matter, but that this matter had no original hereditary power and that its form and other attributes in succeeding generations have been moulded into the environment, and that the burden of proof is thrown upon those who assume that life-matter was endowed with the property that like necessarily produces like. At all events, this last is my own conception of the modification of the streams of ascent.

In other words, I look upon heredity as an acquired character, the same as form or color or sensation is, and not as an original endowment of matter. The hereditary power did not originate until for some reason it was necessary for a given character to reproduce itself, and the longer any form or character was perpetuated, the stronger became the hereditary power.

It is now pertinent to inquire what determined the particular differences which we know to have persisted. The mere statement that some forms became sessile or attached to the earth, and that others became or remained motile, is an assumption that these differences were direct adaptations to environment. Every little change in environment incited a corresponding change in the plastic organization ; and the greater and more various the changes in the physical attributes of the earth with the lapse of time, the greater became the modifications in organisms. I believe, therefore, that the greater part of present differences in organisms are the result directly and indirectly of external stimuli, until we come

into those higher ranges of being in which sensation and volition have developed, and in which the effects of use and disuse and of psychological states have become increasingly more important as factors of ascent. The whole moot question, then, as to whether variations are definite or multifarious, is aside from the issue. They are as definite as the changes in the environment, which determine and control their existence. More differences arise than can persist, but this does not prove that those which are lost are any the less due to the impinging stimuli. Those who write of definite variation, usually construe the result or outcome of some particular evolution into a measure of the variation which is conceived to have taken place in the group. Most or all of the present characters of any group are definite because they are the survivals in a process of elimination; but there may have been, at various times, the most diverse and diffuse variations in the very group which is now marked by definite attributes. As the lines of ascent developed, and generation followed generation in countless number, the organization was more and more impressed with the features of ancestral characters, and these ancestral characters are the more persistent as they have been more constant in the past. But these characters, which appear as hereditary or atavistic variations in succeeding generations, were no doubt first, at least in the plant creation, the offspring, for the most part, of the environment reacting upon the organism. As life has ascended in the time-scale and has become increasingly complex, so the operation of any incident force must ever produce more diverse and unpredictable results. What I mean to say is that, in plants, some of the variations seem to me to be the resultants of a long line of previous incident impressions, or have no immediate inciting cause. Such variation is, to all appearances, fortuitous. It is, therefore, evident that the study of the effects of impinging environments at the present day may not directly elucidate the changes which similar conditions may have produced in the beginning.

Whilst the steadily ascending line of the plant creation was fitting itself into the changing moods of the external world, it was at the same time developing an internal power. Plants were constantly growing larger and stronger or more specialized. The accumulation of vital energy is an acquired character the same as peculiarities of form or structure are. It is the accumulated result of every circumstance which has contributed to the well-being and virility of the organism. The gardener knows that he can cause the plant to store up energy in the seed, so that the resulting crop will be the larger. Growth is itself but the expression or result of this energy which has been picked up by the way through countless ages. Now, mere growth is variation. It results in differences. Plants cannot grow without being unlike. The more luxuriant the growth, the more marked the variation. Most plants have acquired or inherited more growth-force than they are able to use because they are held down to certain limitations by the conditions in which they are necessarily placed by the struggle for existence. I am convinced that many of

the members of plants are simply outgrowths resulting from this growth-pressure, or as Bower significantly speaks of them ("A Theory of the Strobilus in Archegoniate Plants," *Annals of Botany*, viii, 358, 359), the result of an "eruptive process." The pushing out of shoots from any part of the plant body, upon occasion, the normal production of adventitious plantlets upon the stems and leaves of some begonias (especially *Begonia phyllomaniaca*), bryophyllum, some ferns, and many other plants, are all expressions of the growth-force which is a more or less constant internal power. This growth-force may give rise to more definite variations than impinging stimuli do; but the growth-force runs in definite directions because it, in its turn, is the survival in a general process of elimination. Many of the characters of plants which—for lack of better explanation—we are in the habit of calling adaptive, are no doubt simply the result of eruption of tissue. Very likely some of the compounding of leaves, the pushing out of some kinds of prickles, the duplication of floral organs, and the like, are examples of this kind of variation. We know that the characters of the external bark or cortex upon old tree trunks are the result of the internal pressure in stretching and splitting it. This simply shows how the growth-force may originate characters of taxonomic significance when it is expressed as mere mechanical power acting upon tissue of given anatomical structure. This power of growth is competent, I think, to originate many and important variations in plants. I suppose my conception of it to be essentially the same as that of the bathmism of Cope, and the "Theory of the Organic Growth" of Eimer.

We have now considered two general types of forces or agencies which start off variations in plants—purely external stimuli, and the internal acquired energy of growth. There is still a third general factor, crossing, or, as Eimer writes it, "sexual mixing." The very reason for the existence of sex, as we now understand it, is to originate differences by means of the union of two parents into one offspring. This sexual mixing cannot be considered to be an original cause of unlikenesses, however, since sex itself was at first a variation induced by environment or other agencies, and its present perfection, in higher organisms, is the result of the process of continuous survival in a conflict of differences.

The recent rise of Lamarckian views seems to have been largely the result of an attempt to discover the *vera causa* of variations. Darwin's hypothesis of natural selection assumes variability without inquiring into its cause, and writers have therefore said that Darwin did not attempt to account for the cause of variations. Nothing can be farther from his views. Yet some of our most recent American writings upon organic evolution repeat these statements. Cope, in his always admirable *Primary Factors of Organic Evolution*, writes that "Darwin only discussed variation after it came into being." Yet Darwin's very first chapter in his *Origin of Species* contains a discussion of the "Causes of Variability," and the same subject is gone over in detail in *Variation of Animals and Plants Under*

Domestication. Darwin repeatedly refers the cause or origin of variation to "changed conditions of life," which is essentially the position maintained by the Lamarckians, and he as strenuously combats those who hold that definite variation is an innate attribute of life. "But we must, I think, conclude . . . .:" writes Darwin in the latter book, "that organic beings, when subjected during several generations to any change whatever in their conditions, tend to vary!" He discussed, at length, the particular agencies which he considered to be most potent in inducing variability, and enumerated, amongst other factors, the kind and amount of food, climate and crossing. "Changes of any kind in the conditions of life," he repeats, "even extremely slight changes, often suffice to cause variability. Excess of nutriment is perhaps the most efficient single exciting cause." Cope, in his discussion of the "Causes of Variation," starts out with the proposition "to cite examples of the direct modifying effect of external influences on the characters of individual animals and plants;" and he closes with this paragraph: "I trust that I have adduced evidence to show that the stimuli of chemical and physical forces, and also molar motion or use and its absence, are abundantly sufficient to produce variations of all kinds in organic beings. The variations may be in color, proportions, or details of structure, according to the conditions which are present." This is, in great part, the thesis to which Darwin extended the proofs of a most laborious collection of data from gardeners and stock-breeders and from feral nature. It has been the great misfortune of the interpretation of Darwin's writings that his hypothesis of natural selection has so completely overtopped everything else in the reader's mind that other important matters have been overlooked.

Whilst the one central truth in the plant creation is the fact that differences arise as a result of variations in environment, there are nevertheless many exceptions to it. There are various types of differences which are merely incidental or secondary to the main stem of adaptive ascent. Some of these are such as arise from the cessation of the constructive agencies, and others are mere correlatives or accompaniment of type differences. As an example of the former, we may cite the behavior of the potato. By high cultivation and careful breeding, the plant has been developed to produce enormous crops of very large tubers, so heavy a crop that the plant has been obliged to spare some of its energy from the production of pollen and berries for the purpose of maintaining the subterranean product. It is evident that this high state of amelioration can be maintained only by means of high cultivation. The moment there is a let-down in the factors which have bred and maintained the plant, there is a tendency towards a breaking up and disappearance of the high bred type. This is an illustration of the phenomenon of panmixia, as outlined by Weismann, except that the force which has ceased to act is human selection rather than natural selection. "This suspension of the preserving influence of natural selection," Weismann writes, "may be termed Panmixia." In

his opinion, "the greater number of those variations which are usually attributed to the direct influence of external conditions of life, are to be attributed to panmixia. For example, the great variability of most domesticated animals and plants essentially depends upon this principle." In other words, certain differences are preserved through the agency of natural selection, and certain differences are lost; if the organism is removed from this restraining and directing agency, all variations have the chance of asserting themselves. "All individuals can reproduce themselves," Weismann explains, "and thus stamp their characters upon the species, and not only those which are in all respects, or in respect to some single organ, the fittest." I am convinced that this term expresses a very important truth, and one which, as Weismann says, is particularly apparent in domestic animals and plants; but panmixia does not express an incident force. If new differences arise in consequence of the cessation of the directive agency of natural selection, it is because they were first impressed upon the organization by some unaccountable agency; or, if there is simply a falling away from accumulated characters, the residuary or secondary features which appear are probably the compound and often deteriorated result of various previous incident forces. In short, panmixia is a name for a class of phenomena, and it cannot be considered as itself an original cause of variation. It is, to my mind, largely the unrestrained expression or unfolding of the growth-force consequent upon the removal of the customary pressure under which the plant has lived.

3. *The Survival of the Unlike.*

The one note of the modern evolution speculations which has resounded to the remotest corner of civilization, and which is the chief exponent of current speculation respecting the origin and destiny of the organic world, is Spencer's phrase, "the survival of the fittest." This epigram is an epitome of Darwin's law of natural selection, or "the preservation, during the battle for life, of varieties which possess any advantage in structure, constitution or instinct." In most writings, these two phrases —"natural selection" and "the survival of the fittest"—are used synonymously; but in their etymology they really stand to each other in the relation of process and result. The operation of natural selection results in the survival of the fittest. One must not be too exact, however, in the literal application of such summary expressions as these. Their particular mission is to afford a convenient and abbreviated formula for the designation of important principles, for use in common writing and speech, and not to express a literal truth. Darwin was himself well aware of the danger of the literal interpretation of the epigram "natural selection." "The term 'natural selection,'" he writes, "is in some respects a bad one, as it seems to imply conscious choice; but this will be disregarded after a little familiarity." This technical use of the term "natural selection" is now generally accepted unconsciously; and yet there have been recent revolts against it upon the score that it does not

itself express a literal principle or truth. If we accept the term in the sense in which it was propounded by its author, we are equally bound to accept "survival of the fittest" as a synonymous expression because its author so designed it. "By natural selection or survival of the fittest," writes Spencer, "by the preservation in successive generations of those whose moving equilibria happen to be least at variance with the requirements, there is eventually produced a changed equilibrium completely in harmony with the requirements."

It should be said that there is no reason other than usage why the phrase "survival of the fittest" should not apply to the result of Lamarckian or functional evolution as well as of Darwinian or selective evolution. It simply expresses a fact without designating the cause or the process. Cope has written a book upon the "Origin of the Fittest," in which the argument is Lamarckian. The phrase implies a conflict, and the loss of certain contestants and the salvation of certain others. It asserts that the contestants or characters which survive are the fittest, but it does not explain whether they are fit because endowed with greater strength, greater prolificness, completer harmony with surroundings, or other attributes. I should like to suggest, therefore, that the chiefest merit of the survivors is unlikeness, and to call your attention for a few minutes to the significance of the phrase—which I have used in my teaching during the last year—the survival of the unlike.

This phrase—the survival of the unlike—expresses no new truth, but I hope that it may present the old truth of vicarious or non-designed evolution in a new light. It defines the fittest to be the unlike. You will recall that in this paper I have dwelt upon the origin and progress of differences rather than of definite or positive characters. I am so fully convinced that, in the plant creation, a new character is useful to the species because it is unlike its kin, that the study of difference between individuals has come to be, for me, the one absorbing and controlling thought in the contemplation of the progress of life. These differences arise as a result of every impinging force—soil, weather, climate, food, training, conflict with fellows, the strain and stress of wind and wave and insect visitors—as a complex resultant of many antecedent external forces, the effects of crossing, and also as the result of the accumulated force of mere growth; they are indefinite, non-designed, an expression of all the various influences to which the passive vegetable organism is or has been exposed; those differences which are most unlike their fellows or their parents find the places of least conflict, and persist because they thrive best and thereby impress themselves best upon their offspring. Thereby there is a constant tendency for new and divergent lines to strike off, and these lines, as they become accented, develop into what we, for convenience sake, have called species. There are, therefore, as many species as there are unlike conditions in physical and environmental nature, and in proportion as the conditions are unlike and local are the species well defined. But to nature, perfect adaptation is the end; she knows nothing, *per se*,

as species or as fixed types. Species were created by John Ray, not by the Lord ; they were named by Linnæus, not by Adam.

I must now hasten to anticipate an objection to my phrase which may arise in your minds. I have said that when characters are unlike existing characters they stand a chance of persisting ; but I do not desire to say that they are useful in proportion as they are unlike their kin. I want to express my conviction that mere sports are rarely useful. These are no doubt the result of very unusual or complex stimuli, or of unwonted refrangibility of the energy of growth, and not having been induced by conditions which act uniformly over a course of time, they are likely to be transient. I fully accept Cope's remark that there is "no ground for believing that sports have any considerable influence on the course of evolution. . . . . The method of evolution has apparently been one of successional increment and decrement of parts along definite lines." Amongst domestic animals and plants the selection and breeding of sports, or very unusual and marked variations, has been a leading cause of their strange and diverse evolution. In fact, it is in this particular thing that the work of the breeder and the gardener are most unlike the work of nature. But in feral conditions, the sport may be likened to an attribute out of place ; and I imagine that its chief effect upon the phylogeny of a race—if any effect it have—is in giving rise in its turn to a brood of less erratic unlikenesses. This question of sports has its psychological significance, for if the way becomes dark the wanderer invokes the aid of this *ignus fatuus* to cut short his difficulties. Sir William Thompson supposes that life may first have come to earth by way of some meteor, and Brinton proposes that man is a sport from some of the lower creation. It is certainly a strange type of mind which ascribes a self-centred and self-sufficient power to the tree of life, and then, at the very critical points, adopts a wholly extraneous force and one which is plainly but a survival of the old cataclysmic type of mind ; and it is the stranger, too, because such type of explanation is not suggested by observation or experiment, but simply by what is for the time an insuperable barrier of ignorance of natural processes. If evolution is true at all, there is reason to suppose that it extends from beginning to finish of creation, and the stopping of the process at obscure intervals is only a temporary satisfaction to a mind that is not yet fully committed to the eternal truth of ascent. The tree of life has no doubt grown steadily and gradually, and the same forces, variously modified by the changing physical conditions of the earth, have run on with slow but mighty energy until the present time. Any radical change in the plan would have defeated it, and any mere accidental circumstance is too trivial to be considered as a modifying influence of the great onward movement of creation, particularly when it assumes to account for the appearing of the very capstone of the whole mighty structure.

Bear with me if I recite a few specific examples of the survival of the unlike, or of the importance, to organic types, of gradually widening dif-

ferences. Illustrations might be drawn from every field of the organic creation, but I choose a few from plants because these are the most neglected and I am most familiar with them. These are given to illustrate how important external stimuli are in originating variation, and how it is that some of these variations persist.

Let me begin by saying that a good gardener loves his plants. Now, a good gardener is one who grows good plants, and good plants are very unlike poor plants. They are unlike because the gardener's love for them has made them so. The plants were all alike in November; in January, the good gardener's plants are strong and clean, with large dense leaves, a thick stem, and an abundance of perfect flowers; the poor gardener's plants are small and mean, with curled leaves, a thin hard stem, and a few imperfect flowers. You will not believe now that the two lots were all from the same seed-pod three months ago. The good gardener likes to save his own seeds or make his own cuttings; and next year his plants will be still more unlike his neighbor's. The neighbor tries this seed and that, reads this bulletin and that, but all avails nothing simply because he does not grow good plants. He does not care for them tenderly, as a fond mother cares for a child. The good gardener knows that the temperature of the water and the air, the currents in the atmosphere, the texture of the soil, and all the little amenities and comforts which plants so much enjoy, are just the factors which make his plants successful; and a good crop of anything, whether wheat or beans or apples, is simply a variation.

And do these unlikenesses survive? Yes, verily! The greater part of the amelioration of cultivated plants has come about in just this way,—by gradual modifications in the conditions in which they are grown, by means of which unlikenesses arise; and then by the selection of seeds from the most coveted plants. Even at the present day, there is comparatively little plant-breeding. The cultivated flora has come up with man, and if it has departed immensely from its wild prototypes, so has man. The greater part of all this has been unconscious and unintended on man's part, but it is none the less real.

As an illustration of how large the factors of undesigned choice and selection are in the amelioration of the domestic flora, let me ask your attention to the battle of the seed-bags. In the year 1890, the census records show, for the first time, the number of acres in the United States devoted to the growing of seed. I give the acreage of three representative crops, and these figures I have multiplied by the average seed-yields per acre in order to arrive at an approximate estimate of the entire crop produced, and the number of acres which the crop would plant. I have used low averages of yields in order to be on the safe side, and I have likewise used liberal averages of the quantity of seed required to plant an acre when making up the last column:

	Acres.	Average yield per acre.	Approximate crop.	Would plant.
Cabbage,	1,268	200 lbs.	253,600 lbs.	1,014,400 acres.
Cucumber,	10,219	120 "	1,226,280 "	613,140 "
Tomato,	4,356	80 "	368,480 "	1,473,920 "

The last column in this table has particular interest because it shows the enormous acreage which these seeds, if all planted, would cover. We are now curious to know if such areas really are planted to these species, and if they are not, it will be pertinent to inquire what becomes of the seeds. Unfortunately, we have no statistics of the entire acreages of these various truck-garden crops, but the same census gives the statistics of the commercial market gardens of the country. Inquiry of seed-merchants has convinced me that about one-fourth of all the seeds sold in any year go to market gardeners. I have therefore multiplied the census figures of market gardens by four for the purpose of arriving at an estimate of the total acreage of the given crops in the United States ; and I have introduced the last column from the above table for purposes of comparison :

	Acreage of market gardens.	Probable total acreage.	There are seeds enough to plant	Difference.
Cabbage,	77,094	308,376	1,014,400 acres.	706,024 acres.
Cucumber,	4,721	18,884	613,140 "	594,256 "
Tomato,	22,802	91,208	1,473,920 "	1,382,712 "

It will thus be seen that there are enough cabbage seeds raised in this country each year—if the census year is a fair sample—to plant nearly three-quarters of a million acres more than actually are planted ; about the same surplus of cucumber seeds ; and a surplus of tomato seeds sufficient to plant over one and a quarter million acres. It is possible, of course, that the figures of actual acreage of these crops are too low ; but such error, if it occur, must be much overbalanced by the large quantities of home-grown and imported seeds which are used every year. These startling figures would not apply so well to many other crops which are detailed in the census bulletin. For instance, the peas raised in this country would plant only about 46,000 acres, whilst there are over 100,000 acres actually grown ; but this discrepancy is probably accounted for by the fact that the larger part of the seed peas are grown in Canada and therefore do not figure in our census. There is a somewhat similar discrepancy in the watermelon, but in this crop the seeds are very largely home-saved by the heavy planters in the South and West. I do not give these figures for their value as statistics, but simply for the purpose of graphically expressing the fact that many more seeds are raised by cultivators each average year than are ever grown into plants, and that the struggle for existence does not necessarily cease when plants are taken under the care of man.

What, now, becomes of this enormous surplus of seeds? Let us take a rough survey of the entire seed crop of any year. In the first place, a certain percentage of the seeds is laid aside by the seedsman as a surety against failure in the year to come. Much of this old stock never finds its way into the market and is finally discarded. We will estimate this element of waste as twenty per cent. Of the eighty per cent. which is actually sold, perhaps another ten per cent. is never planted, leaving about seventy per cent. which finds its way into the ground. These two items of loss are pure waste and have no effect upon the resulting crop. Now, of the seeds which are planted, not more than seventy-five per cent. can be expected to germinate. That is, there is certainly an average loss of twenty-five per cent. in nearly all seeds—and much more in some—due to inherent weakness, and seventy-five per cent. represents the survival in a conflict of strength. We have now accounted for about half of the total seed product of any year. The remaining half produces plants; but here the most important part of the conflict begins. In the crops mentioned above, much less than half of the seeds which are grown ever appear in the form of a crop. We must remember, moreover, that in making the estimate of the number of acres which these seeds would plant, I have used the customary estimates of the quantity of seeds required to plant an acre. Now, these estimates of seedsmen and planters are always very liberal. Every farmer sows from five to twenty times more seeds than he needs. Some years ago, I sowed seeds according to the recommendation of one of our best seedsmen, and I found that peas would be obliged to stand four-fifths of an inch apart, beets about twenty to the foot, and other vegetables in like confusion. I suppose that of all the seeds which actually come up, not more than one in ten or a dozen, in garden vegetables, ever give mature plants. What becomes of the remainder? They are thinned out for the good of those which are left.

This simple process of thinning out vegetables has had a most powerful effect upon the evolution of our domestic flora. It is a process of undesigned selection. This selection proceeds upon the differences in the seedlings. The weak individuals are disposed of, and those which are strongest and most unlike the general run are preserved. It is a clear case of the survival of the unlike. The laborer who weeds and thins your lettuce bed unconsciously blocks out his ideas in the plants which he leaves. But all this is a struggle of Jew against Jew, not of Jew against Philistine. It is a conflict within the species, not of species against species. It therefore tends to destroy the solidarity of the specific type, and helps to introduce much of that promiscuous unlikeness which is the distinguishing characteristic of domestic plants.

Let us now transfer this emphatic example to wild nature. There we shall find the same prodigal production of seeds. In the place of the gardener undesignedly moulding the lines of divergence, we find the inexorable physical circumstances into which the plastic organisms must grow, if they grow at all. These circumstances are very often the direct

causes of the unlikenesses of plants, for plants which start like when they germinate may be very unlike when they die. Given time and constantly but slowly changing conditions, and the vegetable creation is fashioned into the unlikenesses which we now behold. With this conception, let us read again Francis Parkman's picturesque description of the forest of Maine in his *Half-Century of Conflict:* "For untold ages Maine had been one unbroken forest, and it was so still. Only along the rocky seaboard, or on the lower waters of one or two great rivers a few rough settlements had gnawed slight indentations into this wilderness of woods, and a little farther inland some dismal clearing around a block-house or stockade let in the sunlight to a soil that had lain in shadow time out of mind. This waste of savage vegetation survives, in some part, to this day, with the same prodigality of vital force, the same struggle for existence and mutual havoc that mark all organized beings, from men to mushrooms. Young seedlings in millions spring every summer from the black mould, rich with the decay of those that had preceded them, crowding, choking and killing each other, perishing by their very abundance; all but a scattered few, stronger than the rest, or more fortunate in position, which survive by blighting those about them. They in turn, as they grow, interlock their boughs, and repeat in a season or two the same process of mutual suffocation. The forest is full of lean saplings dead or dying with vainly stretching towards the light. Not one infant tree in a thousand lives to maturity; yet these survivors form an innumerable host, pressed together in struggling confusion, squeezed out of symmetry and robbed of normal development, as men are said to be in the level sameness of democratic society. Seen from above, their mingled tops spread in a sea of verdure basking in light; seen from below, all is shadow, through which spots of timid sunshine steal down among legions of dark, mossy trunks, toadstools and rank ferns, protruding roots, matted bushes, and rotting carcases of fallen trees. A generation ago one might find here and there the rugged trunk of some great pine lifting its verdant spire above the indistinguished myriads of the forest. The woods of Maine had their aristocracy; but the axe of the woodman has laid them low, and these lords of the wilderness are seen no more."

In such bold and generalized examples as this, the student is able to discern only the general fact of progressive divergency and general adaptation to conditions, without being able to discover the particular directive forces which have been at the bottom of the evolution. It is only when one considers a specific example that he can arrive at any just conclusions respecting initial causes of modification. Of adaptive modifications, two general classes have been responsible for the ascent of the vegetable kingdom, one a mere moulding or shaping into the passive physical environments, the other the direct result of stress or strain imposed upon the organism by wind and water and by the necessities of a radical change of habit from aquatic to terrestrial life, and later on by the stimuli of insects upon the flowers. One of the very best examples of the mere pas-

sive ascent is afforded by the evolution of the root as a feeding organ; and a like example of development as a result of strain is afforded by the evolution of the stem and vascular or fibrous system. Our present flora, like our present fauna, is an evolution from aquatic life. The first sessile or stationary plants were undoubtedly stemless. As the waters increased in depth and plants were driven farther and farther from their starting points by the struggle for place and the disseminating influence of winds and waves, the plant body became more and more elongated. Whilst the plant undoubtedly still absorbed food throughout its entire periphery, it nevertheless began to differentiate into organs. The area chiefly concerned in food-gathering became broadened into a thallus, a constricted or stem-like portion tended to develop below, and the entire structure anchored itself to the rock by a hold-fast or grapple. This hold-fast or so-called root of most of our present sea-weeds is chiefly a means of holding the plant in place, and it probably absorbs very little food. As plants emerged into amphibian life, however, the foliar portion was less and less thrown into contact with food, and there was more and more demand upon the grapple which was anchored in the soil. The foliage gradually developed into organs for absorbing gases and the root was forced to absorb the liquids which the plant needed. I do not mean to say that there is any genetic connection between the sea-weeds and the higher plants, or that the roots of the two are homologous; but to simply state the fact that, in point of time, the hold-fast root developed before the feeding root did, and that this change was plainly one of adaptation. Specialized forms of flowering plants, which inhabit water, still show a root system which is little more than an anchor, and the foliage actively absorbs water. The same environmental circumstances are thus seen to have developed organs of similar physiological character in widely remote times and in diverse lines of the plant evolution. "As the soil slowly became thicker and thicker," writes King in his book upon *The Soil*, "as its water-holding power increased, as the soluble plant food became more abundant, and as the winds and the rains covered at times with soil portions of the purely superficial and aërial early plants, the days of sunshine between passing showers, and the weeks of drought intervening between periods of rain, became the occasions for utilizing the moisture which the soil had held back from the sea. These conditions, coupled with the universal tendency of life to make the most of its surroundings, appear to have induced the evolution of absorbing elongations, which, by slow degrees and centuries of repetition, came to be the true roots of plants as we now know them." Some aquatic flowering plants are, as we have seen, still practically rootless and they absorb the greater part of their food directly by the foliar parts; but the larger number of the higher plants absorb their mineral food by means of what has come to be a subterranean feeding organ, and the foliar parts have developed into gas-absorbing organs and they take in water only when forced to do so under stress of circumstances.

But as a mere feeding organ, the root requires no fibrous structure. It is still a hold-fast or grapple and its mechanical tissue has developed enormously, along with that of the stem, in order to preserve the plant against the strain of the moving elements and to maintain its erectness in aërial life. When this self-poised epoch arrives, the vegetable world begins its definite and steady ascent in centrogenic form. Whilst the animal creation leaves its centrogenic arrangement early in its own time-scale, the plant creation assumes such arrangement at a comparatively late epoch in its time-scale.

Perhaps the best illustration which I can bring you of the origin of the unlike by means of environmental conditions and the survival of some of this unlikeness in the battle for life, is the development of the winter quiescence of plants. What means all this bursting verdure of the liquid April days? Why this annually returning miracle of the sudden expansion of the leaf and flower from the lifeless twigs? Were plants always so? Were they designed to pass so much of their existence in the quiescent and passive condition? No. The first plants had no well-defined cycles, and they were born to live, not to die. There were probably no alternations of seasons in the primordial world. Day alternated with night, but month succeeded month in almost unbroken sameness age after age. As late as the Carboniferous time, according to Dana, the globe "was nowhere colder than the modern temperate zone, or below a mean temperature of 60° F." The earth had become wonderfully diverse by the close of the Cretaceous time, and the cycads and their kin retreated from the poles. Plants grew the year round; and as physical conditions became diverse and the conflict of existence increased, the older and the weaker died. So a limit to duration, that is, death, became impressed upon the individuals of the creation; for death, as seen by the evolutionist, is not an original property of life-matter, but is an acquired character, a result of the survival of the fittest. The earth was perhaps ages old, even after life began, before it ever saw a natural death; but without death all things must finally have come to a standstill. When it became possible to sweep away the old types, opportunity was left for new ones; and so the ascent must continue so long as physical conditions, which are not absolutely prohibitive of life, shall become unlike.

Species have acquired different degrees of longevity, the same as they have acquired different sizes and shapes and habits—by adaptation to their conditions of life. Annual plants comprise about half of the vegetable kingdom, and these are probably all specializations of comparatively late time. Probably the greater part of them were originally adaptations to shortening periods of growth, that is, to seasonal changes. The gardener, by forceful cultivation and by transferring plants towards the poles, is able to make annuals of perennials. Now, a true annual is a plant which normally ripens its seeds and dies before the coming of frost. Many of our garden plants are annuals only because they are killed by frost. They naturally have a longer season than our climate will admit, and some of

them are true perennials in their native homes. These plants are, with us, plur-annuals, and amongst them are the tomato, red pepper, egg plant, potato, castor bean, cotton, Lima bean and many others. But there are some varieties of potatoes and other plants which have now developed into true annuals, normally completing their entire growth before the approach of frost. It is all the result of adaptation to climate, and essentially the same phenomenon is the development of the annual and biennal flora of the earth from the perennial. An interesting example of the effect of climate upon the seasonal duration of plants is the indeterminate or prolonged growth of plants in England as compared with the same plants in America. The cooler summer and very gradual approach of winter in England develop a late and indefinite maturity of the season's growth. When English plants are grown in America, they usually grow until killed by fall frosts; but after a few generations of plants, they acquire the quick and decisive habit of ripening which is so characteristic of our vegetation. I once made an extended test of onions from English and American seeds (Bull. 31, Mich. Agric. College), and was astonished to find that nearly all of the English varieties continued to grow until frost and failed "to bottom," whilst our domestic varieties ripened up in advance of freezing weather. This was true even of the Yellow Danvers and Red Wethersfield, varieties of American origin and which could not have been grown very many years in England. Every horticulturist of much experience must have noticed similar unmistakable influences of climate upon the duration of plants.

A most interesting type of examples of the quick influence of climate upon plants—not only upon their duration but upon habit and structural characters—is that associated with the growing of "stock seed" by seedsmen. Because of uncertainties of weather in the Eastern States, it is now the practice to grow seeds of onions, Lima beans and other plants in California or other warm regions; but the plants so readily acquire the habit of long-continuing growth as to be thereafter grown with difficulty in the Northeastern States. It is, therefore, necessary that the seedsman shall raise his stock seed every year in his own geographical region, and this seed is each year sent to California for the growing of the commercial seed crop. In other words, the seed of California-grown onions is sold only for the purpose of growing onion bulbs for market, and is not planted for the raising of a successive crop of seed. This results in growing only a single generation of the crop in the warm country. Onion seed from stock which has been grown in California for several years produces onions which do not "bottom" well, much as I found to be the case with the English onion seed.

But many plants, in geologic time, could not thus shorten up their life-history to adjust themselves to the oncoming of the seasons. They ceased their labors with the approach of the cold or the dry, tucked up their tender tissues in buds and resigned themselves to the elements. If a man could have stood amongst those giant mosses and fern forests of

the reeking Carboniferous time, and could have known of the refrigeration which the earth was to undergo, he would have exclaimed that all living things must utterly perish. Consider the effects of a frost in May. See its widespread devastation. Yet, six months hence the very same trees which are now so blackened, will defy any degree of cold. And then, to make good the loss of time, these plants start into activity relatively much earlier in spring than the same species do in frostless climates. This very day, when frosts are not yet passed, our own New York hillsides are greener with surface vegetation than the lands of the Gulf States are, which have been frostless for two months and more. The frogs and turtles, the insects, the bears and foxes, all adjust themselves to a climate which seems to be absolutely prohibitive of life, and some animals may actually freeze during their hibernation, and yet these April days see them again in heyday of life and spirits! What a wonderful transformation is all this! This enforced period of quiescence is so impressed upon the organization that the habit becomes hereditary in plants, and the gardener says that his begonias and geraniums and callas must have a "rest," or they will not thrive. But in time he can so far break this habit in most plants as to force them into activity for the entire year. These budding days of April, therefore, are the songs of release from the bondage of winter which has come on as the earth has grown aged and cold.

I must bring still one more illustration of the survival of the unlike, out of the abundance of examples which might be cited. It is the fact that, as a rule, new types are variable and old types are inflexible. The student of fossil plants will recall the fact that the liriodendrons, ginkgos, sequoias, sassafrasses and other types came into existence with many species and are now going out of existence with one or two species. Williams has considered this feature, for extinct animal forms, at some length in his new *Geological Biology*. "Many species," he writes, "which by their abundance and good preservation in fossil state give us sufficient evidence in the case, exhibit greater plasticity in their characters at the early stage than in later stages of their history. A minute tracing of lines of succession of species shows greater plasticity at the beginning of the series than later, and this is expressed, in the systematic description and tabulation of the facts, by an increase in the number of the species." "When species are studied historically, the law appears evident that the characters of specific value . . . . present a greater degree of range of variability at an early stage in the life-period of the genus than in the later stages of that period." So marked is this incoming of new types in many cases that some students have supposed that actual special creation of species has occurred at these epochs. It should be said that there is apt to be a fallacy in observation in these instances, because the records which are, to our vision, simultaneous in the rocks may have extended over ages of time; but it is nevertheless true that some important groups seem to have come in somewhat quickly with

many or several species and to have passed out with exceeding slowness.

To my mind, all this is but the normal result of the divergence of character, or the survival of the unlike. A new type finds places of least conflict, it spreads rapidly and widely, and thereby varies immensely. It is a generalized type, and therefore adapts itself at once to many and changing conditions. A virile plant is introduced into a country in which the same or similar plants are unknown, and immediately it finds its opportunity and becomes a weed, by which we mean that it spreads and thrives everywhere. Darwin and Gray long ago elucidated this fact. The trilobites, spirifers, conifers, ginkgos, were weed-types of their time, the same as the composites are to-day. They were stronger than their contemporaries, the same as our own weeds are stronger than the cultivated plants with which they grow. After a time, the new types outran their opportunity, the remorseless struggle for existence tightened in upon them, the intermediate unlikenesses had been blotted out, and finally only one or two types remained, struggling on through the ages, but doomed to perish with the continuing changes of the earth. They became specialized and inelastic; and the highly specialized is necessarily doomed to extinction. Such remnants of a vanquished host remain to us in our single liriodendron, the single ginkgo and sassafras, and the depleted ranks of the conifers.

My attention was first called to this line of thought by contemplating upon the fact that cultivated plants differ widely in variability, and I was struck by the fact that many of our most inextricably variable groups—as the cucurbits, maize, citrus and the great tribes of composites—are still unknown in a fossil state, presumably because of their recent origin. Many other variable genera, to be sure, are well represented in fossil species, as roses (although these are as late as the Eocene), pyrus, prunus and musa; but absolute age is not so significant as the comparative age of the type, for types which originated very far back may be yet in the comparative youth of their development. The summary conclusions of a discussion of this subject were presented to the American Association for the Advancement of Science two years ago.* A modification of these points, as I now understand them, would run something as follows:

1. There is a wide difference in variability in cultivated plants. Some species vary enormously, and others very little.

2. This variability is not correlated with age of cultivation, degree of cultivation, or geographical distribution.

3. Variability of cultivated plants must be largely influenced and directed, therefore, by some antecedent causes.

4. The chief antecedent factor in directing this variability is probably the age of the type. New types, in geologic time, are polymorphous; old types are monomorphous and are tending towards extinction. The most flexible types of cultivated plants are such as have probably not yet

* *Proc. A.A.A.S.* 1894, 255; *Botanical Gazette*, xix. 381.

passed their zenith, as the cucurbits, composites, begonias and the like. The varieties of cereals, which are old types, are so much alike that expert knowledge is needed to distinguish them.

5. New types are more variable and flexible because less perfectly moulded into and adjusted to the circumstances of life than the old types are. They have not yet reached the limits of their dissemination and variation. They are generalized forms.

The reader will please observe that I have here regarded the origin and survival of the unlike in the plant creation in the sense of a plastic material which is acted upon by every external stimulus and which must necessarily vary from the very force of its acquired power of growth, and the unlikenesses are preserved because they are unlike. I have no sympathy with the too prevalent idea that all the attributes of plants are direct adaptations or that they are developed as mere protections from environment and associates. There is a type of popular writings which attempts to evolve many of the forms of plants as a mere protection from assumed enemies. Perhaps the plant features which have been most abused in this manner, are the spines, prickles and the like, and the presence of acrid or poisonous qualities. As a sample of this type of writing, I will make an extract from Massee's *Plant World:*

"Amongst the most prominent and general modes of protection of vegetative parts against the attacks of living enemies may be mentioned *prickles*, as in roses and brambles, which may either be straight, and thus prevent the nibblings of animals, or, in more advanced species, curved, thus enabling the weak stem to climb and carry its leaves out of harm's way. *Spines*, that are sharp-pointed abortive branches, serving the same purpose as prickles, as in the common sloe or blackthorn (*Prunus spinosa*). *Rigid hairs* on leaves and stem, as in the borage (*Borago officinalis*), and comfrey (*Symphytum officinale*). *Stinging hairs*, as in the common nettles (*Urtica dioica*, and *U. urens*). In these cases the stinging hairs are mixed on the leaves and stem with ordinary rigid hairs, of which they are higher developments, distinguished by the lower or basal swollen portion of the hair containing an irritating liquid that is ejected when the tip of the hair is broken off. *Bitter taste*, often accompanied by a strong scent, as in wormwood (*Artemisia vulgaris*), chamomile (*Anthemis nobilis*), and the leaves and fruit of the walnut (*Juglans regia*). *Poisonous alkaloids*, as in the species of *Strychnos*, which contain two very poisonous alkaloids, strychnine and brucine, in the root and the seeds ; decoctions of species of Strychnos are used by the Javanese and the natives of South America to poison their arrows. Some of the species, as *Strychnos nux-vomica*, are valuable medicines, depending on the strychnine they contain, which acts as a powerful excitant of the spinal cord and nerves ; thus the most effective protective arrangements evolved by plants can be turned to account, and consequently lead to the destruction of the individuals they were designed to protect. Our common arum (*Arum maculatum*), popularly known as 'Lords and Ladies,' has an intensely acrid sub-

stance present in the leaves, which effectually protects it from the attacks of mammals and caterpillars, but not from the attacks of parasitic fungi, which appear to be indifferent to all protective contrivances exhibited by plants, nearly every plant supporting one or more of these minute pests, the effects of which will be realized by mentioning the potato disease, 'rust' and 'smut' in the various cereals, and the hop disease, all due to parasitic fungi."

Now, this is merely a gratuitous and *ad captandrum* species of argument, one which is designed to please the fancy and to satisfy those superficial spirits who are still determined to read the element of design into organic nature. It does not account for the facts. These particular attributes of plants are specialized features, and it is always unsafe to generalize upon specializations. Each and every one of such specialized features must be investigated for itself. Probably the greater number of spinous processes will be found to be the *residua* following the contraction of the plant body; others are no doubt mere correlatives of the evolution of other attributes; and some may be the eruptions of the growth-force; and the acrid and poisonous properties are quite as likely to be wholly secondary and useless features. The attempt to find a definite immediate use and office for every attribute in the creation is superficial and pernicious. There are many attributes of organisms which are not only useless, but positively dangerous to the possessor, and they can be understood only as one studies them in connection with the long and eventful history of the line of ascent.

The thought which I want to leave with you, therefore, is that unlikenesses are the greatest facts in the organic creation. These unlikenesses in plants are (1) the expressions of the ever-changing environmental conditions in which plants grow, and of the incidental stimuli to which they are exposed; (2) the result of the force of mere growth; (3) the outcome of sexual mixing. They survive because they are unlike, and thereby enter fields of least competition. The possibility of the entire tragic evolution lay in the plasticity of the original life-plasma. The plastic creation has grown into its own needs day by day and age by age, and it is now just what it has been obliged to be. It could have been nothing else.

Remarks by Prof L. H. Bailey.

Prof. Cope has given us three general proofs or series of proofs of evolution. In the first place he says there is variation; in the second place succession; and in the third place we have the proof of embryology. I might subdivide them and might add two or three more proofs which appeal to me with particular force. It seems to me that we must accept the truth of evolution on the mere fact that the earth from its beginning has undergone wonderful physical changes, affecting the organisms living upon it, and which must have adapted themselves to the changes by them-

selves changing. In the second place, we know that there must be an intense struggle for existence amongst all forms of life; that the result of this struggle for existence must be adaptation to the organic environment. Again, another line of proof that evolution is true is the classificatory verification. The very fragment of the tree of life which Prof. Cope has put upon the board is an evidence that there are converging histories of animals, or, in other words, that there are relationships. But the proof which appeals to me most strongly is the fact that gardeners and breeders have it in their power to make new forms and that they have been making them since man began to deal with plants and animals. The palæontological and embryological records do not appeal to me with such force as the experiences of breeders and gardeners, who for ages have been modifying plants and animals almost to suit their will. This, of course, suggests that I am not skilled in the sciences of palæontology and embryology; but have given more attention to gardening.

I assume that you all believe in evolution. Heredity is not a necessary attribute of the theories of evolution. It is a matter for the physiologists and the embryologists to discuss rather than for one who looks broadly at nature and tries to discover some of the general and fundamental facts which have determined the onward progress of creation. I wish to call your attention to the facts of the origin of differences. I speak of differences rather than of variations.

Dr. D. G. Brinton made the following remarks:

We have listened with interest to this able exposition of the principles of evolution from three eminent scholars approaching it from different points of view. The question proposed, however, was one which was intended to go beyond the mere facts of natural science. Facts are not factors. The word means something more, something deeper. When we have these series of facts laid before us, however interesting they may be, they do not themselves express the primary law of evolution, but are merely a number of incidents illustrative of it. Therefore I think that the first speaker in his clear descriptions of the palæontologic evolutionary claims gave us little information as to the factors which brought them about.

We shall no doubt grant, as was urged by the second speaker, that there are extrinsic and intrinsic factors of evolution; but what he advanced as extrinsic factors were again series of external facts, and his intrinsic factors were series of internal facts or processes. The law by virtue of which they acted upon organic forms so as to produce a varying morphology was not, it seems to me, definitely stated.

By the third speaker the doctrine of evolution has been put forward as a sort of religious dogma of the scientific church. For myself, I cannot look upon it in that light. I believe I caught his words correctly when I quote him as saying that evolution holds good "from beginning to finish

of creation." I cannot see that any known facts justify such a statement. Evolution is a matter of the past not of the future. We have nothing to do with the "finish of creation," and it is not likely that we know anything about it. Such a dogma has no place in scientific bodies. All we know is, that of the many millions of organized species a few have developed into higher forms, while the immense majority have perished utterly. We have no guarantee but that evolution has reached its acme and may cease to-night. Let us hold it, therefore, as a fact of past time, not as a dogma of faith regarding the future.

Turning now to the question of the evening, What are the ultimate factors or primary causes, so far as we can trace them, which have influenced and do influence the development of organic forms? For an answer I turn to an expression once used by my teacher, Prof. James D. Dana, whose name is a household word to every man of science. His suggestive expression was, "The whole of Nature is bound in a straight-jacket of mathematics." It means that we must go back to the purely mechanical forces of the universe, if we would find the primary factors of organic variation. The last speaker well said that mutability, change, not permanence, is the law of organic life. He developed it admirably in his references to the like and the unlike, and in his statement that unlikeness is really the secret of advance. This theory, as doubtless some will remember, was that brought forward with force and beauty by the late eminent Dr. Pasteur in his remarkable papers on *Asymmetry* as the source of change in both the organic and inorganic worlds. Unquestionably he was right. Change is the law of the universe. It is no new perception of the thinking mind. Nigh two thousand years ago the philosopher Heraclitus of Ephesus laid down the principle, "All is flowing," *παντα ρει.* No two organic forms are alike, or can be alike. The son is never the image of his father; the plant never finds in its product the precise reproduction of itself. You remember how Leibnitz amused the ladies of the court by having them try to find two leaves of an oak which were alike. They tried in vain. Never anywhere is uniformity or identity; everywhere is indefinite, infinite variability.

What is the explanation of this?

I ask your attention again to the mechanical principles of nature. To them alone must we return when we search for primary agencies of change. All organic and inorganic substances are constantly subject to the innumerable forces which play upon them from all parts of the universe. Every atom of earth is influenced by each distant star. Constantly each atom is bombarded by thousands, by millions of forces, and its changes are the resultants of these.

The primary laws of motion with which we are familiar in the *Principia* of Newton are also the primary causes both of the permanence and the variability of organic forms. His first law—that motion would continue forever in the same direction unless interfered with by other motion in

another direction—gives us the stability of species, the potent tendency of the individual to transmit the specific characteristics, the maintenance of traits by the germinal protoplasm, as brought out by the second speaker. It is the *conatus in se perseverare* of Spinoza.

The second law of motion is the basis of all change and variation It is, as doubtless you remember, that change of motion is proportional to force and takes place in the line of the force. Infinite forces infinitely different in power are forever acting on every atom, and its changes are the resultants of them all.

These ceaseless changes are purely mechanical, and mechanical laws produce their results absolutely without regard to future aims, absolutely indifferent to the quality of results, whether towards evolution or degeneration. For that reason. I repeat that any dogmatic assumption of evolution as a law of nature is unscientific. Of a million changes, a few may act in so strengthening the energy of the primary and permanent characters that they will resist the deterrent or subversive action of other forces So far as we know, this is mere chance. Purely mechanical forces decide the progress of a species or its extinction. Beyond such mechanical, mathematical laws, natural science has no right to go.

In conclusion, I would say a few words in reference to "sports," a topic introduced by the last speaker. These sudden and extensive changes received the careful attention of Darwin, who in his work on the *Domestication of Animals and Plants*, refers to it by the term "spontaneous variation . . . ." He pointed out that in some cases it is extraordinarily great and also permanent, as in the instance of the niata cattle in La Plata. In the vegetable world, Mr. Meehan has illustrated this form of change by numerous and striking examples. The last speaker mentioned that the lines of species had not been traced through sports. I would call attention to the obvious fact that the origin of what are called specific peculiarities from a sport would be likely to cause the scientific investigator to lose the trail at that point. Darwin says that nothing but the record would reconcile us to believing that such sports as some he describes issued from the species to which they belong.

How unconsidered then is the remark of the last speaker in reference to those who have suggested that man himself may have owed his specific peculiarity to such an origin! There is nothing impossible in this, nothing incredible, nothing absurd. When our ancestors ascended from the plane of the beast to that of reasoning intelligence, a part of the path may have been won by one of those bounds which have been called saltatory evolution. There is nothing in this contrary to either theory or observation. It is supported by both; and having once gained that higher plane, they would not willingly have forfeited its advantages.

Further remarks by Prof. L. H. Bailey:

Dr. Brinton has quoted me as saying, "From beginning to finish of creation, evolution is true." He quoted me correctly. That is my own

conviction. I have no proof. I have no proof that the sun will rise to-morrow. But the greater the collection of facts and of data which we make respecting the evolution of the world in the past, the more are the changes seen to be continuous and gradual; and it seems to me that if evolution has taught us anything it has been to show that there is a law of evolution, continuous throughout time. I believe, myself, that evolution is true from beginning to finish of creation; and if we could not prophesy that our race has nobler possibilities for the future I should lose my zest to live.

Spontaneous variations are not necessarily sports in the sense in which I refer to them. Sports are those forms of variation which appear to lie outside the general or customary type of variation of the species—or phylum—with which we are dealing. They are those forms which are so unusual as to be ordinarily considered to be a taxonomic variety or division or subspecies. The causes of sports are unknown to us, as are also the causes of all spontaneous differences which may be of much less moment. The fact that Darwin dwelt upon the origin of sports in domestic animals is a matter which I discussed in my paper and, I believe, it is the chief line of effort in which man's work differs from nature's—the fact that he does save the sports and breed them up. I have no evidence that nature does the same; and so far as the plant creation is concerned, I am more and more convinced that sports have had but comparatively small influence upon the phylogenies of our present types.

I wish to add just one word in reference to a matter which Prof. Conklin introduced. He took issue with Prof. Cope with respect to the doctrine of natural selection and the notion that Darwin did not attempt to account for variation. The doctrine of natural selection itself does not account for variation. It has been the misfortune of Darwin's writings that his doctrine of natural selection has been so emphasized as to overshadow everything else which he did. Amongst the causes of variability which Darwin enumerates are external stimuli, soil, weather, food, climate and other impinging factors; so that Darwin conceived the idea that impinging stimuli were the causes of variations which, when they have arisen, have been bred up by natural selection.

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EXTRACT FROM THE LAWS.

CHAPTER XII.

OF THE MAGELLANIC FUND.

SECTION 1. John Hyacinth de Magellan, in London, having in the year 1786 offered to the Society, as a donation, the sum of two hundred guineas, to be by them vested in a secure and permanent fund, to the end that the interest arising therefrom should be annually disposed of in premiums, to be adjudged by them to the author of the best discovery, or most useful invention, relating to Navigation, Astronomy, or Natural Philosophy (mere natural history only excepted); and the Society having accepted of the above donation, they hereby publish the conditions, prescribed by the donor and agreed to by the Society, upon which the said annual premiums will be awarded.

CONDITIONS OF THE MAGELLANIC PREMIUM.

1. The candidate shall send his discovery, invention or improvement, addressed to the President, or one of the Vice-Presidents of the Society, free of postage or other charges; and shall distinguish his performance by some motto, device, or other signature, at his pleasure. Together with his discovery, invention, or improvement, he shall also send a sealed letter containing the same motto, device, or signature, and subscribed with the real name and place of residence of the author.

2. Persons of any nation, sect or denomination whatever, shall be admitted as candidates for this premium.

3. No discovery, invention or improvement shall be entitled to this premium, which hath been already published, or for which the author hath been publicly rewarded elsewhere.

4. The candidate shall communicate his discovery, invention or improvement, either in the English, French, German, or Latin language.

5. All such communications shall be publicly read or exhibited to the Society at some stated meeting, not less than one month previous to the day of adjudication, and shall at all times be open to the inspection of such members as shall desire it. But no member shall carry home with

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XXXV. AUGUST, 1896. NO. 151.

Stated Meeting, May 15, 1896.

The Treasurer, MR. PRICE, in the Chair.

Present, 52 members.

Minutes of May 1 were read and approved.

Letters of envoy from the Geological Survey of India, Calcutta; Observatoire Physique Central, Société Impériale Russe de Geographie, St. Petersburg, Russia; Societas pro Fauna et Flora Fennica, Helsingfors, Finland; Université Royale, Lund, Sweden; K. Sächsische Gesellschaft der Wissenschaften, Leipzig; Bath and West and Southern Counties Society, Bath, Eng.; Royal Observatory, Greenwich, Eng.; Meteorological Office, R. Statistical Society, London, Eng.; Missouri Geological Survey, Jefferson City.

Letters of acknowledgment from R. Zoologisch Gesellschaft "Natura Artis Magistra," Amsterdam, Netherlands (148); Zoöl. Botan. Society, The Hague, Holland (148); Colonial Museum (148); Fondation de P. Teyler van der Hulst, Harlem, Holland (148, and *Trans.* xvi, 1, 2); Maatschappij der Nederlandsche Letterkunde, Leiden, Holland (148); Université Royale, Lund, Sweden (147); Prof. Japetus Steenstrup, Copenhagen, Denmark (148); Musée Royal d'Histoire Naturelle de Belgique, Bruxelles (148); R. and T. Observatory, Prague, Austria (148); Dr. H. Rollett, Baden bei Wien (143, 146–148); K. K. Central Anstalt. für Meteorologie und Erdmagnetismus.

(148); Dr. Aristides Brezina (145); Prof. Gustav Tschermak, Vienna, Austria (142, 144); Anthropologische Gesellschaft, Prof. Dr. Reuleaux, Berlin, Prussia (148); Vogtländische Altertumsforschenden Verein, Hohenleuben, Saxony (148); Dr. O. Böhtlingk, Prof. I. Victor Carus, Leipzig, Saxony (148); K. Sternwarte (148), Dr. Paul Thyse, Munich, Bavaria (147, 148); K. Geodätische Institut, Potsdam, Prussia (148); Institut de France, Dr. E. T. Hamy, Profs. Gaston Maspero, Leon de Rosny, Paris, France (148); Mr. Samuel Timmins, Arley, Coventry, Eng. (148); Profs. C. A. M. Fennell, R. T. Glazebrook, J. P. Postgate, Cambridge, Eng. (148); Phil. and Lit. Society, Leeds, Eng.; Royal Society, Victoria Institute, R. Astronomical Society, R. Meteorological Society, R. Geological Society, Royal Institution, R. Geographical Society, Society of Antiquaries, R. Statistical Society, Sir Henry Bessemer, Col. William Ludlow, Sir James Paget, Prof. W. C. Unwin, London, Eng. (148); Geographical Society, Manchester, Eng. (148); Lit. and Phil. Society, New Castle-on-Tyne, Eng. (148); Radcliffe Observatory, Prof. James Ligge, Oxford, Eng. (148); R. Geological Society of Cornwall, Penzance, Eng. (148); Dr. Isaac Roberts, Starfield, Crowborough, Sussex, Eng. (148); Nat. Hist. and Phil. Society, Belfast, Ireland (148); Royal Society, Prof. James Geikie, Edinburgh, Scotland (148); Society of Natural History, Portland, Me. (148, 149); Mass. Agricultural College, Amherst (149); Prof. Alpheus Hyatt, Dr. Justin Winsor, Cambridge, Mass. (149); Amer. Antiquarian Society, Worcester, Mass. (149); Amer. Mathematical Society (148), Amer. Institute Electrical Engineers, New York, N. Y. (149), Prof. Lyman B. Hall, Haverford, Pa. (149); Prof. John F. Carll, Pleasantville, Pa. (149); Philosophical Society, West Chester, Pa. (148); U. S. Naval Institute, Annapolis, Md. (148, 149); Maryland Historical Society, Baltimore (149); Smithsonian Institution, Washington, D. C. (144, 145, 146); N. C. Experiment Station, Raleigh (149); Ohio State Archæol. and Hist. Society, Columbus (149); Prof. H. T. Eddy, Minneapolis, Minn. (147–149); Kansas Historical Society, Topeka (149); Observatorio Astronómico Mex-

icano, Tambaya, Mexico (149); Rt. Rev. Crescencio Carrillo, Merida, Yucatan (149); Société Scientifique du Chili, Santiago (141).

Letters of acknowledgment (*Transactions*) from the Museum of Comparative Zoölogy, Cambridge, Mass.; Amer. Antiquarian Society, Worcester, Mass.; Yale University, New Haven, Conn.; The Buffalo Library, Buffalo, N. Y.; Historical Society, Astor Library, New York, N. Y.; U. S. Military Academy, West Point, N. Y.; Haverford College, Haverford, Pa.; Academy Nat. Sciences, Historical Society of Pennsylvania, Library Company, Philadelphia (xviii, 3); Johns Hopkins University, Baltimore, Md. (xvi, 2, 3; xvii, 1, 2, 3; xviii, 1, 2, 3).

Accessions to the Library were reported from the Société des Naturalistes, Kieff, Russia; Société des Naturalistes, Moscow, Russia; K. Russische Geog. Gesellschaft, Phys. Central Observatoriums, K. Mineralogische Gesellschaft, St. Petersburg, Russia; Societas pro Fauna et Flora Fennica, Helsingfors, Finland; I. R. Accad. di Scienze, Lettere, etc., Degli Agratis Roveredo, Austria; K. P. Meteorol. Institut, K. Museums für Völkerkunde, Gesellschaft für Anthropologie, Ethnologie, etc.; Prof. A. Bastian, Berlin, Prussia; Direcção Trabalhos Geologicos de Portugal, Lisboa; Instituto y Observatorio de Marina, San Fernando, Spain; Bath and West and Southern Counties Society, Bath, Eng.; Royal Observatory, Greenwich, Eng.; Literary and Philosophical Society, Liverpool, Eng.; Literary and Philosophical Society, Manchester, Eng.; Hon. J. M. Lemoine, Quebec, Canada; Free Library, Boston, Mass.; Zoölogical Society, Mr. William A. Ingham, Philadelphia; Chief of Engineers, Committee to Establish the University of the United States, Department of Labor, Prof. Alexander Graham Bell, Washington, D. C.; Missouri Geological Survey, Jefferson City; University of Michigan, Ann Arbor; Agricultural Experiment Stations, Lafayette, Ind.; Brookings, S. Dak.; Observatorio Meteorol., Leon, Mexico; Direccion General de Estadistica, Guatemala, C. A.; Museo Biblioteca de Filipinas, Manilla.

Dr. Morris, of the Curators, called attention to photographs presented by Mrs. Stevenson of the relics found in Egypt.

Also, on behalf of Robert Patterson Field, he presented a portrait in oil of Dr. Robert M. Patterson.

The Report of Council was read, in which nominations 1332, 1334, 1357, were recommended to be postponed for written information.

The resolution presented at the meeting of March 20 was recommended for approval, amended to read as follows:

Resolved, That papers by non-members presented to the Society shall be read by title only, except when the author is present or by consent of two-thirds the members present.

Prof. A. H. Smyth then read an obituary notice of Henry Phillips, Jr.

The stated business being the election of members, Secretary DuBois and Dr. Hays were made Tellers. The names were read and spoken to and the ballots cast.

The following papers were then read by title and referred to the Secretaries:

"Second Contribution to the History of the Cotylosauria" by E. D. Cope; "Sixth Contribution to the Knowledge of the Marine Miocene Fauna," by E. D. Cope; "On Natural Selection and Separation," by Arnold E. Ortman; "Notes on the Osteology of the White River Horses," by Marcus S. Farr.

Dr. Frazer announced that Mr. Barkley had brought from New York specimens of results of color photography according to the system of Mr. Joly, and had placed them in Mr. Sachse's hands.

Mr. Sachse then explained the system and exhibited the specimens.

Dr. Frazer then advocated the reproduction in *facsimile* of our signature book for distribution among the members, and the matter was referred to the Secretaries with power to act.

The Tellers reported the result of the ballot, and the following were declared elected:

2282. Edward S. Dana, New Haven, Conn.

NEGATIVE.

POSITIVE.

PRINTS ILLUSTRATING THE JOLY PROCESS.

2283. C. Hanford Henderson, Ph.D., Philadelphia.
2284. Chas. Sedgwick Minot, Harvard Univ., Mass.
2285. L. H. Bailey, Ithaca, N. Y.
2286. Wm. H. Welch, M.D., Baltimore, Md.
2287. T. Mitchell Prudden, M.D., New York City.
2288. John Trowbridge, Harvard Univ., Mass.
2289. Nikola Tesla, New York City.
2290. Arthur W. Wright, Ph.D., New Haven, Conn.
2291. Prof. Henry A. Rowland, Baltimore, Md.
2292. Prof. Arthur W. Goodspeed, Philadelphia.
2293. Prof. Michael I. Pupin, New York City.
2294. Thos. A. Edison, Orange, N. J.
2295. Edw. C. Pickering, Cambridge, Mass.
2296. Frank H. Cushing, Washington, D. C.

The Joly Process of Color Photography.

By Julius F. Sachse.

(Read before the American Philosophical Society, May 15, 1896.)

I have the honor to present to your notice this evening, by courtesy of Mr. Richard Barkley, of New York, a series of specimens illustrating the so-called "Joly" process of color-photography.

They are the same as were lately shown before the Royal Society of England, and excited considerable attention.

This process, although it depends upon the three primary color sensations, differs materially from all others thus far brought to the notice of the public, because but a single photographic manipulation is required, and no apparatus is needed other than such as is used in ordinary every-day photography.

This process consists in making a negative through a closely-lined screen, ruled in three colors, viz., orange, yellow-green and blue-violet. The screens used in the specimens here shown were made with an ordinary ruling pen, such as is used by draughtsmen, and the lines number about two hundred to the inch. A finer ruling in the future will make the lines which we now see in the specimens before us less prominent.

It will be noticed that Prof. Joly, in his "taking" screen, which is here before you, has substituted, for the usually accepted primary color

sensations, red, green, blue, the colors orange, yellow-green and blue-violet. Experience has taught him that not only were the former colors unsuitable for the purpose, but that to reproduce the effect of natural colors, a somewhat different screen must be used over the resultant positive image. For this purpose Prof. Joly rules a screen in pure red, green and blue-violet. This he calls his viewing screen.

[For the red-selecting lines of the "taking" screen, Prof. Joly uses a spectrum color, such as that to be found at one-sixth of the distance from the line D to the line C; for the green-selecting lines he uses a color corresponding to that of the spectrum at about one-third of the distance from the E line to the D line; and for the blue-violet-selecting lines he uses a color corresponding to the spectrum color near the F line, but toward the G line. On comparison of the "taking" screen with the spectrum, these colors can be called a red-orange, yellow-green, and a violet-blue. For the colors of the "viewing" screen he uses a pure red not far from the C line; a green near the E line; and for the blue-violet lines he takes a spectrum color between G and H, the object being in the "viewing" screen to transmit fundamental color sensations only, and to let the eye do its own mixing; the eye is assisted by the depth of light and shade in the linear areas of the positive; for instance, if the full amount of light of two adjacent red and green lines be transmitted, the eye sees a yellow; if now some of the green be obstructed or shut out by the positive over it, then the eye will see an orange; and if, on the other hand, some red be shut out by the positive, then the eye sees a yellow-green, and it is easy to see that one can run all the colors from pure red to pure green by the varying amounts of the red or green lines shut out by the positive.]

The first specimen we have here is a negative of a china plate and jug, photographed through the "taking" screen.

The next one is a glass positive printed in contact from the above negative. It will be noticed that neither of these specimens differ from ordinary photographic results except that lines due to the use of the screen are somewhat prominent.

The third specimen is a positive similar to the one just shown, placed in register with a "viewing" screen; and by holding it up to the light, and viewing it through the ruled grating, we see the china plate and jug in the bright colors of the original objects.

The next subject is a male portrait from life; this illustrates the possibility of the process in its application to professional portraiture.

We now have a portrait of an "Irish peasant girl," not from life, it is true, but from a water color, which is here before us. The specimen labeled No 7 is placed in contact with a "viewing" screen. The original is here offered for comparison, so that you may judge of the fidelity of the reproduction to the colors of the original. To prove the correctness of his theory, Prof. Joly here presents another specimen of the same subject, No. 12. This is taken and placed in contact with the same

("taking") screen. The great difference and the falsity of the color rendering will at once be noted by comparison with the original.

The next specimen is perhaps the most interesting one of all, on account of being an almost instantaneous picture.* It represents a military band in the Park of Trinity College, Dublin. It will be noted that the bright reds of the uniform coats are exceptionally well rendered. Further, this example indicates a possible application of this method of color reproduction to snap-shot photography.

I now wish to call your attention to an interesting feature of this process, viz., the necessity for having the photograph and screen in exact register, and viewing it in a normal position. Viewed direct, this transparency shows the colors of nature: the brilliant red hue of the coats is especially noticeable. Now if we turn the transparency so as to view it at a slight angle, we at once note a change of the colors, and, in this particular instance, an apparent change of the nationality of the subjects: in place of English soldiers in bright red coats, we see a body of men dressed in brilliant green: in short, the Englishman appears to have been turned into an Irishman of the most pronounced type.

The next subject is a perfect representation of a green fluorescent bowl made of uranium glass.

We now come to another interesting specimen—a photograph of a bunch of wall flowers, executed in two color sensations only, viz., the red and green sensations. This picture derives an additional interest from the fact that it was made by Prof. Joly at the request of Lord Kelvin, to show the effect of "violet blindness," an extremely rare variety of color-blindness.

I now present to your notice two photographs of the solar spectrum from nature—the first one made through a "taking" screen, and seen through a "viewing" screen, which, as you will perceive, shows some of the principal lines; the other one, both taken and viewed through the "viewing" screen, shows a false color rendition. The yellow passing through the red lines only, is almost entirely represented by pure red. The incorrectness of the result is evident on comparing it with the first specimen or with nature.

I now come to the commercial part of this process. I have here for your inspection a specimen of three-color printing: the original photograph consists of a single negative; the printing was done from three separate half-tone blocks or plates—red, yellow and blue.

This result is obtained by making three positives in the camera from the original negative in the following manner: A special screen is prepared with black lines twice the width of those upon the taking screen, the intervening space being the width of a single line. This screen, when placed in register with the original negative, it will be observed, exposes only every third line of the negative. Now it will be obvious that if this screen be moved the width of a single line before each

*Actual time about three seconds.

exposure, we shall obtain three positives, each showing but one-third of the original negative, and at the same time representing a different color sensation. An ordinary half-tone plate is now made from each positive, in the usual manner, and then printed successively in yellow, red and blue inks, the same as in the ordinary chromo-typographic or three-color process.

In the case under consideration you will note the almost perfect result, without the presence of the objectionable mathematical cross-line hatch-work.

This latter adaptation of the Joly process, I am informed, is the invention of two young men in this country; and should it prove practical and give certain results, it will without doubt be a great step forward in chromo-typography, and also have commercial value.

It is a curious fact that the foundations of the interesting processes I have described are based, and depend for their ultimate success, upon the ruling machine—an invention of Joseph Saxton, a former member of this Society, specimens of whose early photo-mechanical reproductions, made in 1841, are still in our possession.

In conclusion, I will state that the one great advantage which this process seems to offer over other schemes in heliochromy or the three-color process, is the fact that but a single negative is required, which is obtained by the ordinary methods of photography, so that all special or intricate apparatus, with uncertain results, are obviated. It will be further noted that the specimens shown here to-night are among the earliest ones made, with crude appliances as to the ruling of the screens and the pigments.

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*Second Contribution to the History of the Cotylosauria.**

By E. D. Cope.

(*Read before the American Philosophical Society, May 15, 1896.*)

The examination of new material derived from the Permian formation of Texas enables me to make some important additions to the knowledge of the Cotylosaurian Reptilia, as set forth in my synopsis published in these PROCEEDINGS for November, 1895 (p. 437).

In the first place, I have to describe a type new to the order, and which resembles nothing hitherto found in the Permian beds of North America, or apparently elsewhere. It must be referred to a new family with the following name and characters.

* Read before the U. S. National Academy of Sciences, April, 1896.

OTOCŒLIDÆ.

Posterior border of temporal roof excavated laterally by the meatus auditorius externus. Teeth present in a single row, not transversely expanded. Ribs immediately overlaid by parallel transverse dermoössifications which form a carapace.

In the presence of the meatus auditorius this family differs from the other members of the Cotylosauria. In the latter the vestibular space is enclosed by the lateral part of the temporal roof, and has no distal inferior bounding wall. The meatus results in the Otocœlidæ not merely from the excavation of this roof but also from the excavation of the posterior border of the suspensorium. In Conodectes this excavation is not great, but in Otocœlus it is very considerable, the proximal extremity of the suspensorium having the anterior position seen in the Loricata and Testudinata. It resembles the quadrate of the latter order in the decurvature of the proximal extremity into a descending hook, which partially bounds the meatus posteriorly.

This meatal excavation constitutes an approximation in the Cotylosauria to other and later orders of Reptilia, where it is nearly universal. It is interesting to observe that it precedes in time the division of the roof into longitudinal bars by perforation, in the series of which the Otocœlidæ form a part. This fact renders it probable that it is from this family that the order of the Testudinata has descended. It may also be found that the Pseudosuchia have the same origin. The carapace of the Otocœlidæ approaches nearly that of the genus Typothorax* Cope, of the Trias; where each rib is expanded, and bears above it a distinct dermosseous band of equal width, with a sculptured surface. This genus probably belongs to the Pseudosuchia, whose type genus Aëtosaurus Fraas, has a carapace consisting of transverse bands of osseous plates in mutual contact. The transverse segmentation of the carapacial bands of Otocœlus would produce such a structure. The same character is found in the genus Episcoposaurus Cope of the Trias, where the cranium is unknown. A reduction of the number of the transverse bands of the Otocœlidæ would approximate the carapace to that of the Testudinata. The arrangement of the clavicles and episternum is quite like that of the corresponding elements in the anterior lobe of the plastron in the tortoises. The median and posterior part of the abdominal wall of the Otocœlidæ is unknown. The teeth are quite insignificant,

*In the last edition of Dana's *Geology*, 1895, p. 758, it is inaccurately stated that "A large Crocodilian of the genus Belodon has been described by Cope . . . . under the name of *Typothorax coccinarum*." The fact is, that two animals were included in the description, which I afterwards determined to belong to different genera. The one for which I reserved the name Typothorax does not belong to the genus Belodon. See *Proc. Amer. Philos. Soc.*, 1887, p. 200, Plate I, where the genus and species are defined. Recently Marsh has described (*Amer. Journ. Sci. Arts*, July, 1896, p. 61) the cast of a similar reptile from the Trias of Connecticut, to which he gives the name *Stegomus arcuatus*. He does not distinguish the supposed new genus Stegomus from Typothorax.

and their loss would bring us again to the Testudinata type. Their implantation in deep alveoli is reptilian in character.

I have pointed out that the notch in the posterior border of the cranial table in the stegocephalous Batrachia was probably covered by a membranum tympani, since the stapes terminates there. This notch is the first appearance of a meatus auditorius in the Vertebrata, and it is not present in all Stegocephalia. It seems that the members of the Cotylosauria differ among themselves similarly, some presenting the meatus, and others lacking it. In Conodectes the character approaches that of the Stegocephalia more nearly than it does in Otocœlus.

In the *American Naturalist* for 1885, p. 247, I published the conclusion that the Testudinata were descended from the Theromora. In my system at that time the Theromora included the Cotylosauria. In 1892 (*Trans. Amer. Philos. Soc.*, p. 24), I distinguished the Cotylosauria as the primitive source of the Testudinata. The discovery of the Otocœlidæ renders it almost certain that this anticipation was correct.

In this family the slight posterior concavity of the quadrate region of the Diadectidæ is extended forwards to a great distance, and the osseous tympanum is produced further outwards. The position of the parts is different from that which is characteristic of the Stegocephalia, where the tympanic notch, when present, is superior, owing to the much greater length of the suspensorium. The dental characters also distinguish this family from the Diadectidæ. No ossicula auditus were found in the tympanic cavity.

Two genera of this family are known, and are characterized as follows:

Mandible articulated much anterior to cranial border; nostrils opening vertically.. *Otocœlus* Cope.
Mandible articulated posteriorly and on line of posterior border of skull; nostrils opening horizontally.............. *Conodectes* Cope.

Two species of Otocœlus and one of Conodectes are known from the Permian bed.

OTOCŒLUS TESTUDINEUS, *Amer. Naturalist*, 1896, 399.

Char. gen.—Teeth with simple subconic crowns. Mandibular ramus not produced posterior to quadrate. Superior cranial bones strongly sculptured.

This genus is established on a skull from which the muzzle anterior to the orbits has been broken off. On its under side, pushed forwards out of place, are a considerable part of the shoulder-girdle, the head of the humerus and a bone of the forearm. On another block, which was found with it, is a part of the carapace, two vertebræ, numerous ribs and both hind legs, lacking the tarsus and digits. The legs and vertebræ were not found attached to the foreleg and the skull, but the actual contact of the corresponding parts is found in the type specimen of another species, the *O. mimeticus*.

There is considerable resemblance between several parts of this animal and those of the stegocephalian Batrachia. This is seen in the forms of the femur and of the shoulder-girdle, which are similar to those which I have referred to Eryops. The close approximation of the huge auricular meatus to the orbit is only seen elsewhere in the anurous Batrachia. The teeth on the other hand are of strictly reptilian type in their mode of implantation, and the lack of dentinal inflections distinguishes them from those of many of the genera of Stegocephalia. There is nothing in the shoulder-girdle to distinguish it from the Cotylosauria, and the humerus so far as preserved is of the type of that order. It is impossible to get at the occipital condyles without destroying important parts of the specimen. The vertebræ are amphicœlous.

It is probable that in life the species of this genus had an enormous tympanic drum.

The tabular part of the skull is large as compared with the facial part. Its posterior border is broken in the *O. testudineus*, but it is continued to a transverse line posterior to the auditory meatus. It was not probably produced into horn-like processes. The suspensorial part of the quadrate is directed posteriorly below. The mandibular ramus has a horizontal expansion of the inner side just anterior to the short angle.

The clavicles have the distal expansion overlapping the episternum characteristic of the order. The shaft makes an obtuse angle with the expanded portion, and is compressed. Its proximal extremity is expanded into a rounded disc, whose plane is horizontal and at right angles to that of the shaft. Between the shaft and the mandibular angle the edge of the pterygoid is visible. The episternum has the posterior part broken off. The part preserved is a transverse plate, which has, like the clavicles, a smooth surface. The scapula lacks the proximal end. Distally it presents a strong longitudinal ridge which extends to the coracoid. Anteriorly the shaft expands into a procoracoid laminar extension in its plane. The coracoid is small and has a convex internal border, which is not notched as in the Pelycosauria. It may be coössified with the scapula. The humerus has a greatly expanded head and a narrow shaft.

The femur is longer than the tibia, and displays the condyles characteristic of the Cotylosauria and Pelycosauria. They are unequally produced posteriorly. There is a long and strong anterior crest.

Two vertebral centra are only moderately well preserved. They are probably anterior dorsals. They are wider than long and are separated by a large and protuberant intercentrum. A free intercentrum of the same shape lies at one side. It is probable that a rather short neural spine rises to the inferior side of the carapace. Only the part next the carapace can be seen in the specimen.

The ribs are much expanded, but do not touch each other. The carapacial bands alternate with them above, resting on their adjacent edges and separated by narrow interspaces. Towards the supposed

anterior part, the superior costal surfaces rise between the carapacial bands to the plane of the latter, forming a closer surface than posteriorly.

This genus forms a remarkable example of homoplastic resemblance to the rhachitomous genus Dissorhophus, which I described in the *American Naturalist* for November, 1895. The superficial resemblance is very great, and it is only after an examination of the constitution of the carapace that the difference of this part of the structure in the two genera is observed. In the batrachian genus the ribs are free from and not in contact with the carapace, and the inferior stratum of the latter consists of the expanded neural spines. (See Plate X.)

Char. specif.—Muzzle very short and broadly rounded. Top of head between and posterior to orbits flat. Orbits directed principally upwards. Intertympanic width 2.5 times interorbital width. Table of skull posterior to orbits about as long as wide. Postorbital width (longitudinal) half as great as interorbital width, which is equal transverse diameter of orbit. Long diameter of orbit obliquely directed outwards and forwards. Malar bar narrow. Quadratojugal surface posteriorly overhanging border of mandible a little, and these contracted to an apex overhanging angle of mandible posteriorly. Mandibular angle undivided. The superior surfaces of the skull have a strongly impressed honeycomb sculpture, the ridges between the pits being frequently interrupted. The sculpture extends to the inferior border of the mandible. The pits average 2 mm. in diameter. The sculpture is present on the external surface of the posttympanic hook, where the decurved border is concave. The median parts of the frontal and parietal bones are smooth, but whether this is normal or is the result of weathering I do not know.

The mandibular ramus presents, a short distance anterior to the angle, a horizontal expansion with convex border directed inwards and in contact with the pterygoid.

The crowns of the teeth are acute and smooth. They overlap the edge of the lower jaw and are separated by interspaces equal to their own diameter. They are of quite small size.

The articular face of the humerus extends downwards on the inner border of the head; perhaps it is restricted to this part of the latter. The section of the shaft is semicircular.

The fragment which contains the vertebræ, hind leg and carapace, does not form a fit with any fractured face of the mass containing the skull. As, however, everything about the two blocks is harmonious, and as they were found close together, I have no doubt of their pertinence to the same skeleton. The second block is split longitudinally, so that only one-half of the carapace is preserved; but at the supposed proximal end enough of the middle portion remains to include the two vertebræ already described. A portion of one hind leg, including the distal part of the femur with the tibia and fibula, lie over the carapace

externally, while the three principal elements of the other leg lie on the inferior side of the carapace. Both legs are extended in the same direction, *i. e.*, forwards.

The shaft of the femur has a triangular section, the external face concave owing to the prominence of the anterior crest. The external condyle is produced further posteriorly than the internal, and is a continuation of the general distal surface and is not reflected on the posterior face as in so many of the Pelycosauria. The anterior face is flat above and shallowly concave at the condylar border below. The head of the tibia is expanded and the shaft narrowed, as in Pelycosauria. It is straight, while the fibula presents towards it a concave outline; and the two extremities of the latter are about equally expanded.

The surfaces of the vertebral centra are slightly concave anteroposteriorly. The intercentra are somewhat swollen and knob-like on the inferior face. It is probable that the ribs are less closely adherent to the carapacial bars posteriorly than anteriorly. As already remarked, anteriorly the ribs emerge between the bars to form part of the surface; medially the ribs are below the bars but touch them. Further posteriorly a cross section displays a rib which does not touch a bar, except perhaps at the extremity, as the curvature would indicate; but this part is broken off. The superior surfaces of the carapacial elements are of dense bone marked with coarse and fine fossæ and intervening elevations irregularly distributed.

The size of this animal is about that of the adult of the larger Japanese salamander, Megalobatrachus.

Measurements.

	MM.
Width of skull between meatus auditorius	75
" " " " orbits	31
" " " " orbit and meatus	15
" " orbit, transversely	27
Length of skull above posterior to orbits	65
Depth of malar bone at middle of orbit	12
" " mandible " " " "	14
Length of tooth exterior to alveolus	3
" " clavicle (chord)	78
Widths of clavicle { proximal	22
Widths of clavicle { median	4
Widths of clavicle { distal	21
Transverse diameters humerus { head	35
Transverse diameters humerus { shaft	5
Length of femur	67
Anteroposterior diameter of femur { proximally	23
Anteroposterior diameter of femur { distally	20
Length of tibia	51

Measurements.

	MM.
Long diameter of head of do	17
" " " distal end of do	13
Length across ends of six ribs	75
" of part of carapace preserved	105
Width of a posterior carapacial bar	10
" " an anterior " "	8
Diameters of a vertebra { anteroposterior	8
Diameters of a vertebra { transverse	16
Diameters of intercentrum { anteroposterior	6
Diameters of intercentrum { transverse	12

OTOCŒLUS MIMETICUS, sp. nov.

This species is represented by a skull with lower jaw in place, which is connected by a band of matrix to a carapace, and some of the bones of one of the limbs. Greater and smaller parts of thirteen bands of the carapace are preserved.

The skull is short and wide. The superior surface is nearly flat from the posterior border to between the nostrils. The muzzle does not project beyond the mouth border. The orbits and nostrils are not superior in direction, although the superior orbital border is excavated. The nostrils are directed forwards and a little laterally; they are separated by a space equal to the transverse diameter of each. The auricular meatus is large and is directed outwards and not upwards. The posterior hooks of the quadrate project on each side beyond the slightly concave posterior border of the cranial table. Interorbital region flat, considerably wider than the diameter of the orbit.

The carapace commences at a point about as far posterior to the skull as the posterior border of the latter is behind the orbits. The anterior band has an obtuse anterior border like that of the anterior border of the carapace of an armadillo. The bands are gently convex from side to side, and they become narrower anteroposteriorly as we pass backwards. The state of the specimen is such that neither ribs nor vetebræ can be discovered.

As compared with the *O. testudineus* the following differences appear. The table of the skull projects beyond the posterior hook of the quadrate in the former; not so far in the latter. The auricular meatus and orbit present more laterally in the *O. mimeticus*, more vertically in the *O. testudineus*. The size of the two species is not very different.

Measurements.

	MM.
Length of skull on middle line	120
Width " " at posterior border of orbits	90
" " " between orbits	38
" " " " nostrils	22

Measurements.

	MM.
Length of skull (median) to anterior border of orbits ..	78
Distance from skull to carapace........................	65
Length of thirteen carapacial bands....................	155
Anteroposterior diameter of first band..................	17
" " " seventh band...............	12

The species is named to express the superficial resemblance to the *Dissorhophus articulatus.*

CONODECTES FAVOSUS, gen. et sp. nov.

Char. gen.—Quadrate bone extending posteriorly so that the mandibular articulation is opposite the posterior border of the cranial table. Meatus auditorius small, connected with a meatal notch. Nostrils directed upwards and a little outwards. Teeth conic, acute, increasing in length to the middle of the maxillary region.

This genus is of much interest, as it displays the character of the family in a less pronounced degree than the genus Octocœlus, and thus approximates more nearly the other forms of Cotylosauria. Its structure illustrates how the meatus auditorius has arisen by the emargination and excavation of the posterior part of the cranial roof of the Cotylosauria. In the other families the access of the internal ear to the external median is closed by the thin temporal roof.

Char. specif.—Established on a cranium with lower jaw in place, which lacks the left half posterior to the orbit, and a piece from the middle of the right side. Both nostrils and a part of the border of the left orbit are preserved, together with the teeth as far posteriorly as the orbit, the premaxillaries imperfectly. A large part of the palate is preserved. The teeth preserved show that the premaxillary teeth are small as in the *Isodectes megalops*, and that they increase in length posteriorly. The maxillopalatines are excavated on the median line so as to present two parallel ridges which continue as far as the posterior border of the internal nares. These ridges probably continue on the palatine bone and they support each a tooth near the posterior extremity. In *Isodectes megalops* the palatines support numerous small teeth on their inner borders. I find no trace of the interior rows of maxillary and mandibular teeth which are characteristic of the Pariotichidæ. Some such teeth may, however, have existed, as a portion of the maxillary bone is wanting from both sides of the skull.

This species is seven or eight times the linear dimensions of the *Isodectes megalops*, and a little smaller than the *Otocœlus testudineus*. The skull is as wide posteriorly as it is long, and is rather depressed, so that the orbits and nares have a vertical as well as a lateral presentation. The muzzle is flat and projects beyond the lower jaw, and it is rounded in outline, and not narrowed and portuberant as in most of the species of Pariotichus. The internareal and interorbital regions are flat. The

narrower brain case is continued between the orbits, and its lateral walls are robust. The palatine bones extend from the maxillaries, and approximate each other nearly on the median line, where they are separated medially by a groove, which becomes wider posteriorly. No teeth can be discerned in the specimen, excepting the large anterior one already mentioned. The surface of the bone is, however, not in good condition. The plate of the pterygoid extends to the jugal on each side, and its posterior border is but little deflected, and is at right angles to the long axis of the skull, with indications of teeth. The posterior branch of the pterygoid is slender. The occipital region is injured. The superior surface of the skull is sculptured, on the posterior frontal region in a coarse honeycomb pattern, the ridges occasionally forming small tubercles.

The teeth are conic, acute, and with a round section. In this respect they differ from those of most of the species of Pariotichus, where the crowns are obtuse. They are rather closely placed, and they increase in length to below the anterior border of the orbit. Their character posterior to this point cannot be ascertained. The single, large palatine tooth is similar to the maxillaries in form, and equals in dimensions the maxillary tooth which is below the posterior border of the nostril. The posterior border of the internal nostril marks a point half way between the posterior border of the anterior nostril and the anterior border of the orbit.

Measurements.	MM.
Total length of skull	158
Width posteriorly	152
Width between nostrils	20
Length from end of muzzle to posterior border of pterygoid plate	103
Width between summits of ridges of vomer	10
Length from posterior border of nostril to anterior border of orbit	41
Length of longest maxillary tooth	10
Diameter of longest maxillary tooth at base	3.5

A part of the muzzle of a second individual was found at the same locality.

DIADECTIDÆ.

I am now able to make some additions to the family of the Diadectidæ. I omitted also in my recent synopsis* of the genera to include the genus Phanerosaurus Von Meyer, from the Permian of Germany, which I had previously referred to this family.† A revision of the species

* *Proc. Amer. Philos. Soc.*, 1895, December, p. 441.

† *Transac. Amer. Philos. Soc.*, 1892, p. 13.

indicates a somewhat different generic reference to that which I have hitherto adopted, as the generic characters have only now become clear to me. The following are the generic characters as I now understand them:

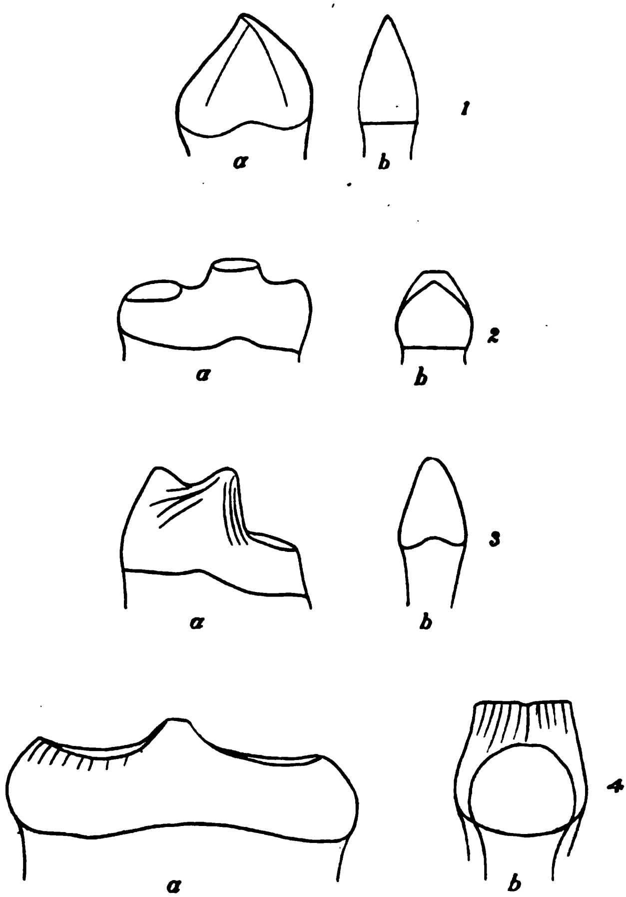
I. Posterior maxillary teeth transverse, depressed, molariform, the heel (external above, internal below) broad and flat.
Skull without dermal or osseous sutures................*Empedias* Cope.
II. Posterior maxillary teeth compressed, transverse, with non-molariform edge or apex, except on wear.
a Teeth with an external heel, besides the apical cusp.
Cranial bones coössified; dermal scuta few or none.....*Diadectes* Cope.
aa Teeth with a cusp only.
Adult cranium sutureless...............................*Bolbodon* Cope.
Cranium with osseous but no dermal sutures......*Phanerosaurus* V. M.
Cranium with both osseous and dermal sutures..........*Chilonyx* Cope.

The species of these genera are the following:

Empedias fissus Cope.
" *molaris* Cope.
Diadectes sideropelicus Cope.
" *phaseolinus* Cope.
" *latibuccatus* Cope.
" *biculminatus* Cope.
Bolbodon tenuitectus Cope.
Phanerosaurus naumannii Von Meyer.
" *pugnax* Gein. u. Deichm.
Chilonyx rapidens Cope.

The above species are from the Permian bed of Texas, excepting the two species of Phanerosaurus, which are from the corresponding horizon in Germany. This genus displays the hyposphen-hypantrum articulation in a less perfect degree than it appears in the American genera where it is known, but it is nevertheless present. It presents conspicuously other characters of the family in the broad closely articulating neural arches, and short, robust neural spines

The molar teeth of three of these genera are represented in the accompanying figures. Nos. 1 and 4 are superior molars, and Nos. 2 and 3 are inferior molars. Their parts are reversed in the two jaws.



1. *Bolbodon tenuitectus*. 2. *Diadectes phaseolinus*. 3. *Diadectes biculminatus*. 4. *Empedias fissus*.

a. Posterior view.
b. End view.

The new forms of the family are as follows:

DIADECTES BICULMINATUS, sp. nov.

As this species is represented by a fragment of a mandible the characters can be drawn from the teeth only. These are remarkable for

their compressed form, and for the unequal elevation of the grinding surface. There is a median cusp much elevated above an external heel, which is at the base of the crown ; and there is an internal cusp which is fused to the median cusp, and reaches a similar elevation. It is doubtful whether there are any interalveolar walls, as the teeth are closely placed.

The internal cusp is a little more elevated than the median, and its apex is separated from that of the latter by a shallow notch. The outer wall of the median cusp is vertical, while the inner wall of the inner cusp is convex both vertically and anteroposteriorly. The worn section of the two is unequally dumbbell-shaped. The external face of the median cusp exhibits a median rib, with a groove on each side, besides finer grooves, which are also present on the anterior faces of the crown near the external border. Internal to these, the median cusp sends shallow grooves obliquely inwards and downwards, which do not reach the base of the internal cusp. The transverse diameter of the crowns diminishes gradually posteriorly, so that the alveolus of the last one of the series is small and round.

The groove which separates the teeth from the external parapet of the jaw is half as wide as the width of the molars. Its edge is roughened with projections which separate fossæ and foramina of different sizes. The external surface of the jaw is roughened with innumerable wrinkles and tubercles separated by grooves, fossæ and foramina.

Measurements.	MM.
Length of series of nine teeth	46
Width of crown of largest molar	13
Elevation of external heel	5
" " internal cusp	11
Anteroposterior diameter	5
Width of mandibular ramus at do.	26

The specimen by which this species is known was found by Mr. J. C. Isaac in 1878. It is the "No. 2" of my description of *Diadectes sideropelicus* of the *Proc. Amer. Philos. Soc.*, 1878, p. 505.

DIADECTES SIDEROPELICUS Cope, *loc. cit.*

This species is represented by a left maxillary bone which contains three molar teeth in place and spaces for five or six others. A simple tooth at its anterior part is larger than is usual in the species of this family. I have accordingly defined the genus Diadectes as characterized by the presence of a canine tooth. It is, however, not possible to determine whether the other simple teeth may not have been of equal proportions, as they are represented by alveoli in the specimen. I therefore define the genus by the molar characters, which are distinct. In this respect the species *D. latibuccatus* and *D. phaseolinus* agree with it. In the last-

named the heel of the molars is larger than in the two others, approaching remotely the genus Empedias. The *D. latibuccatus* differs from the *D. sideropelicus* in the smaller number of molar teeth, and smaller and more numerous caniniform teeth.

BOLBODON TENUITECTUS, gen. et sp. nov.

Char. gen.—Molar teeth without external heel, and with one median cusp. Cranial bones coössified; no grooves indicating the sutures of dermal scuta. Internal borders of palatine bones in mutual contact, and dentigerous.

The dentition of this genus is not different from that of Phanerosaurus, as described and figured by Geinitz and Deichmüller.* In that genus, according to these authors, the cranial elements are distinct, the sutures being persistent. In Bolbodon the cranial elements are entirely coössified, excepting only the tabular bone, which is distinguishable. The nostril is large, and a turbinal bone is visible within it as in Pariotichus. The lateral and inferior bones of the brain case, and the mandible, are not preserved.

Char. specif.—This species is represented by a portion of the cranium, which includes nearly the entire right side, and a portion of the median part of the superior wall from the tabular border to the premaxillary inclusive. The vomer and the middle portions of the palatines, with the right premaxillary and maxillary bones, are preserved.

From the middle line at the apex of the vomer to the posterior extremity of the maxillary bone there are alveoli for seventeen teeth. Of these six only are occupied by teeth, which are numbers 5, 7, 10, 12, 13, 16. Of these only numbers 5, 13 and 16 have perfect crowns. The skull has been somewhat distorted by pressure, so that the longer axis of the roots and crowns are somewhat oblique to their correct positions. The roots of numbers 5 and 7 are wide-oval in section, and the long axis becomes longer posteriorly up to the number 16, in which it is a little contracted, and where the entire dimensions are smaller. The crown of number 5 is caniniform and acute, is curved backwards as to its anterior face, and has a worn posterointernal face due to the opposing tooth of the inferior series. In number 13 the crown is much more expanded transversely, and the external vertical border is convex medially and incurved above and below. Curved shallow grooves radiate from the external apex downwards and inwards. The crown of the sixteenth tooth is cordiform, with the acute apex upwards. Shallow grooves descend from the latter. Like the maxillary teeth the palatines are widely spaced. The sections of their crowns are a wide oval placed longitudinally; apices lost.

The nostril is large and is rounded subquadrate. The orbit is large and is subround, and its border is not notched as in the *Diadectes latibuccatus*, nor the superior border depressed as in *D. phaseolinus*. The

* *Mittheilungen min.-geol. u. præhist. Museum of Dresden*, 1882, p. 10.

interorbital space is gently convex, and is wider than the diameter of the eye, but how much wider the state of the specimen leaves uncertain. The jugal bone is quite narrow below the orbit, its vertical diameter equaling two-fifths that of the latter. The surface of the cranium is rather minutely wrinkled, and does not display the grooves seen in the *Diadectes latibuccatus*. The tabular bone forms a rounded and narrowed cap of the posterolateral angle of the skull, and is much less prominent than in the genus Chilonyx, but more so than in Diadectes, where it is not distinguishable by suture.

Measurements.		MM.
Total length of cranium from premaxillary border to os tabulare inclusive		284
Diameters of nostril	vertical	25
	transverse	33
Distance from nostril to orbit		78
Diameters of orbit	vertical	53
	transverse	54
Interorbital width (posterior to middle)		70
Length of dental series (chord)		150
Diameters m. v	longitudinal	15
	anteroposterior	7
	transverse	10
Diameters m. xii	longitudinal	13
	anteroposterior	6.5
	transverse	13
Diameters m. xvi	longitudinal	10
	anteroposterior	5
	transverse	8.5

The dimensions of this skull are equal to those of the *Diadectes phaseolinus*, and about one-fourth larger than those of the *D. latibuccatus*. The bones of the cranium are thinner and lighter than those of any other species of the family that has come under my observation.

PARIOTICHIDÆ.

PARIOTICHUS ADUNCUS, sp. nov.

Represented by a cranium of which the muzzle and right side, with the right ramus of the mandible, are preserved, together with some other fragments, of one individual; and by a distorted cranium of a second.

The species is intermediate in size and characters between the type of the genus *P. brachyops* and the larger *P. aguti*, besides presenting a number of peculiarities of its own. The elongate maxillary teeth are graded in size to the smaller, and the sixteenth from behind, the largest,

is nearer the anterior border of the orbit than to the nostril. In front of it are three teeth which are preceded by an interval. There are three and perhaps four incisors on each side, of which the external two are small and the internal two very large, the inner the largest. The mandibular teeth increase regularly in length anteriorly. The nostrils are lateral and absolutely terminal. The premaxillary bones are recurved so that the alveolar edge is in vertical line with the posterior border of the nostril. Thus this recurvature exceeds that seen in any other species of the genus, and the symphysis mandibuli is correspondingly posterior. The orbits are larger than in any other species, exceeding the interorbital width considerably, and equaling the length of the muzzle from the orbit to the middle of the nostril. The muzzle is wide above in proportion to its length. It is probable that the width of the skull behind does not exceed the length from the posterior border to the front of the orbit, though this measurement is uncertain owing to the mutilated condition of the right side.

The surface is sculptured with shallow pits separated by rather thick ridges. The nasal bones send back a short angle of the external margin to meet the inferior prefrontal suture, about halfway between the orbit and nostril.

Measurements.	MM.
Length of skull to end of os quadratum	54
" " posterior to orbit	18
" orbit	15
Length from orbit to nostril	12
Width of muzzle at middle	15
" interorbital space	10
" internareal "	8
Length of recurved part of premaxillary	7
" premaxillary I, 1	5
" longest maxillary tooth	4
Depth of mandible at middle of orbit	6

From the Permian formation of Texas.

? PARIASAURIDÆ.

LABIDOSAURUS HAMATUS Cope, gen. nov. *Pariotichus hamatus* Cope, *Proc. Amer. Philos. Soc.*, 1895, p. 448, Pl. viii, Figs. 1 and 2.

Char. gen.—One series of pleurodont maxillary teeth slightly unequal in size. Internal incisor much enlarged, conic, acute, and directed backwards. No teeth on the maxillopalatines; teeth on the palatines small, subconic, in one row. Nostrils lateral.

Better specimens of the above species show that it has but one row of maxillary teeth, which are pleurodont, so that it is clearly a member of a genus distinct from Pariotichus. If the character I have assigned as

definitive of the Pariotichidæ be the true one, the genus Labidosaurus must be referred to a different one, and I know of no character at present to separate it from the Pariasauridæ of which the known species are so far as known up to the present time restricted to South Africa. It differs from the known genera of that family in the greatly elongate premaxillary teeth, and in the simple conic dental crowns.

Char. specif.—Specimens since received display numerous characteristic peculiarities not preserved in the type. The sculpture of the cranial surfaces is in shallow fossæ with rather thick partitions, of smaller size than in the *Pariotichus aguti*, which resembles it most nearly. Thus there are a dozen ridges between the orbits on the front in the latter, while there are fifteen to seventeen in the *L. hamatus*. The maxillary teeth are relatively smaller than in any of the species of Pariotichus known, and they extend only to below the middle of the orbit. The orbit is subround; in the type it is oval, perhaps owing to pressure. Its diameter is about half the length of the skull, both anterior and posterior to it, and equals the interorbital width. The nostril is anteroposteriorly oval, and the apex of the elongate incisor tooth is below its anterior part. Thus, though the muzzle is more elongate than in any of the species of Pariotichus, it does not project so far beyond the premaxillary border. Length of skull of new specimen 155 mm.

APPENDIX ON A SPECIES OF TRIMERORHACHIS.

TRIMERORHACHIS CONANGULUS, sp. nov.

Size, the least of the species of the genus. Angle of the mandible produced, conic. Orbits rather large, the posterior border nearer the line of the end of the muzzle than to the posterior extremity of the mandibular angle, but not so near as to the posterior border of the tabular bone. External nares half way between orbit and end of muzzle. Interorbital width equal diameter of orbit.

Teeth small, the crowns elongate and acute. Twenty-two may be counted from the posterior end of the series to a point opposite the anterior border of the orbit. A much larger tooth is situated on the external border of the maxillopalatine ("vomer"), a little distance in front of the choanæ, while an equally large one is situated directly on the posterior border of the latter. Another tooth of equal size is situated external to the posterior tooth, near the maxillary border, and the base of a smaller one is visible beneath the two.

The mandibular ramus becomes quite slender anteriorly. Posteriorly, the sutures of the angular, articular, dentary and splenial, are distinct. The symphysis projects beyond and turns up in front of the premaxillary border. The angle projects considerably beyond the quadrate, and is rounded below and at the sides. The extremity is vertically grooved, but whether accidentally or normally I cannot determine.

The elements composing the cranial roof are mostly distinguishable.

The supraoccipitals have considerable extent on the superior face of the skull. The largest bones are the parietals, whose median suture is interrupted by the foramen at about the middle. The next largest bone is the tabular, which extends half the length of the parietal forwards. The supramastoid is pyriform and is rather small, and its anterior angle is wedged in between the posterior parts of the postfrontal and postorbital. The postfrontals separate the frontals from the orbital border. The frontals are distinct, and their posterior border is about in the line of the posterior borders of the orbits. The supratemporal region is injured, and only the suture between the quadratojugal and jugal is visible.

The sculpture consists of radiating ridges from some point in each bone to its circumference. This point may be near the centre or one of the borders of the bone. The ridges may be more or less interrupted and inosculating. They are present on the lower jaw as well as the upper.

Measurements.	MM.
Length of skull on base including symphysis	40
Width of skull at quadrate articulations	36
Length of mandibular angle from do	6
Transverse diameter of orbit	5
Length from posterior border of skull to orbit	18
Width between nostrils	10

From the Permian bed of Texas.

EXPLANATION OF PLATES.

Plate VII.

Otocœlus testudineus Cope; parts of skull and skeleton with carapace, from above; two-thirds natural size.

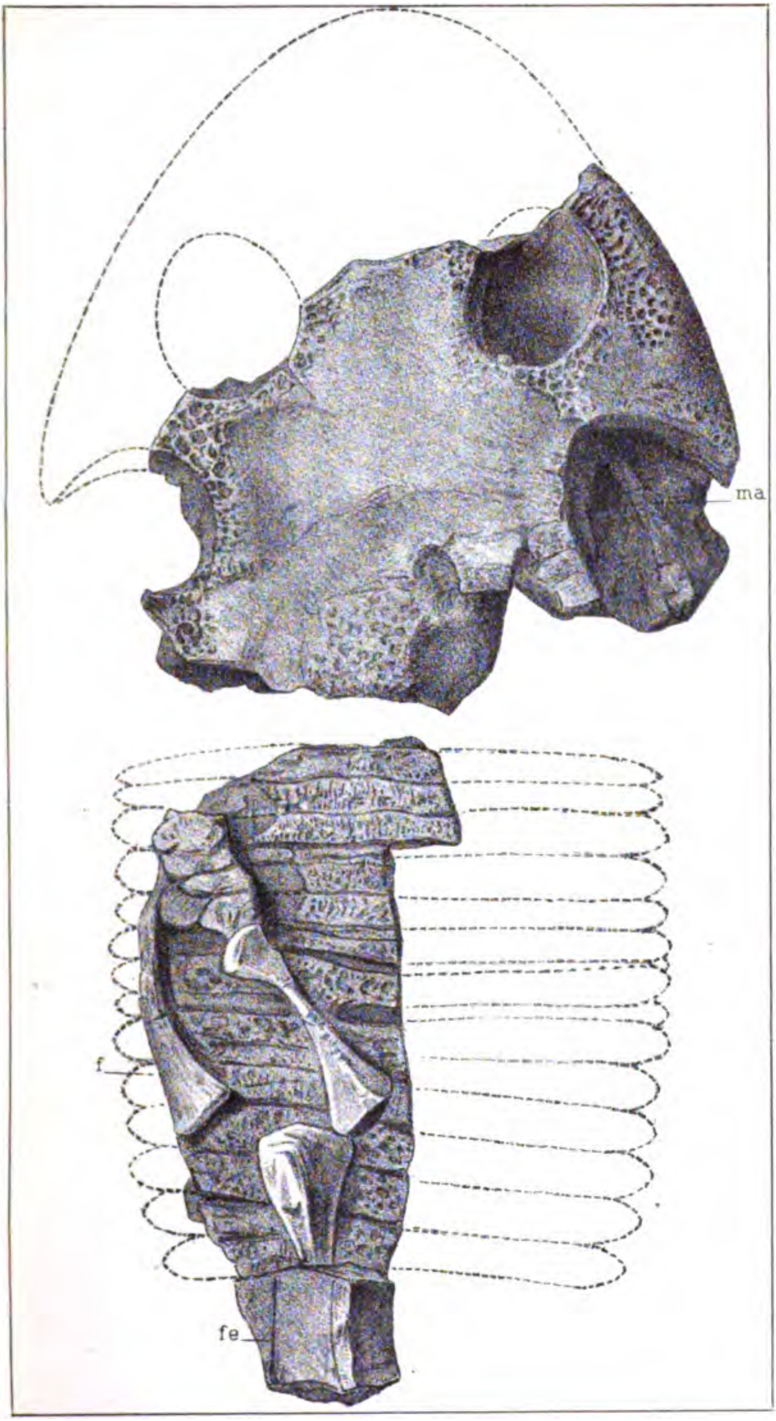
Plate VIII.

Otocœlus testudineus Cope; specimen figured on preceding plate, from below; two-thirds natural size.

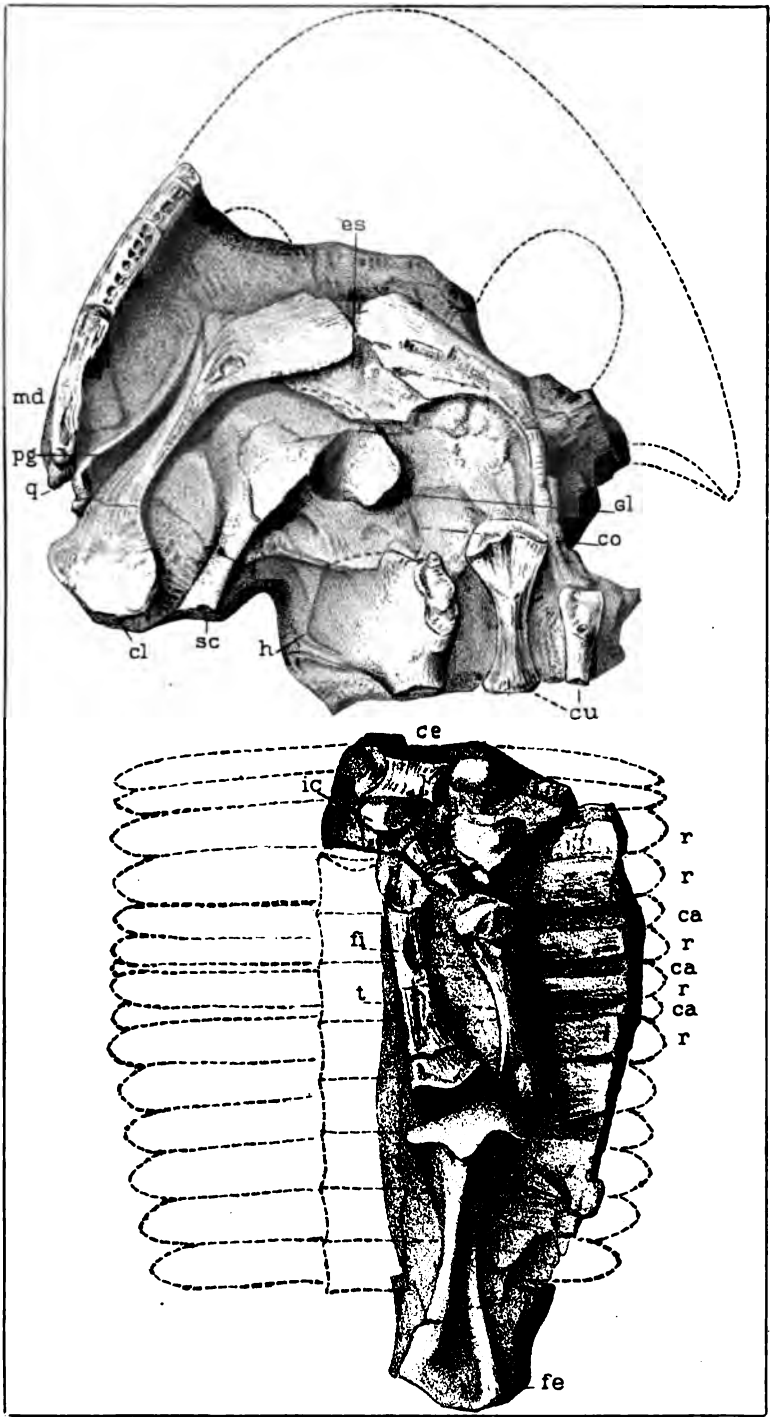
Plate IX.

Fig. 1. *Otocœlus mimeticus* Cope; skull and part of carapace in continuous relation in the matrix, from above; three-fifths natural size.

Fig. 2. *Otocœlus testudineus* Cope; broken edge of typical specimen representing sections of ribs and carapacial bands near the vertebral column; two-thirds natural size.



OTOCOELUS TESTUDINEUS COPE 2/3



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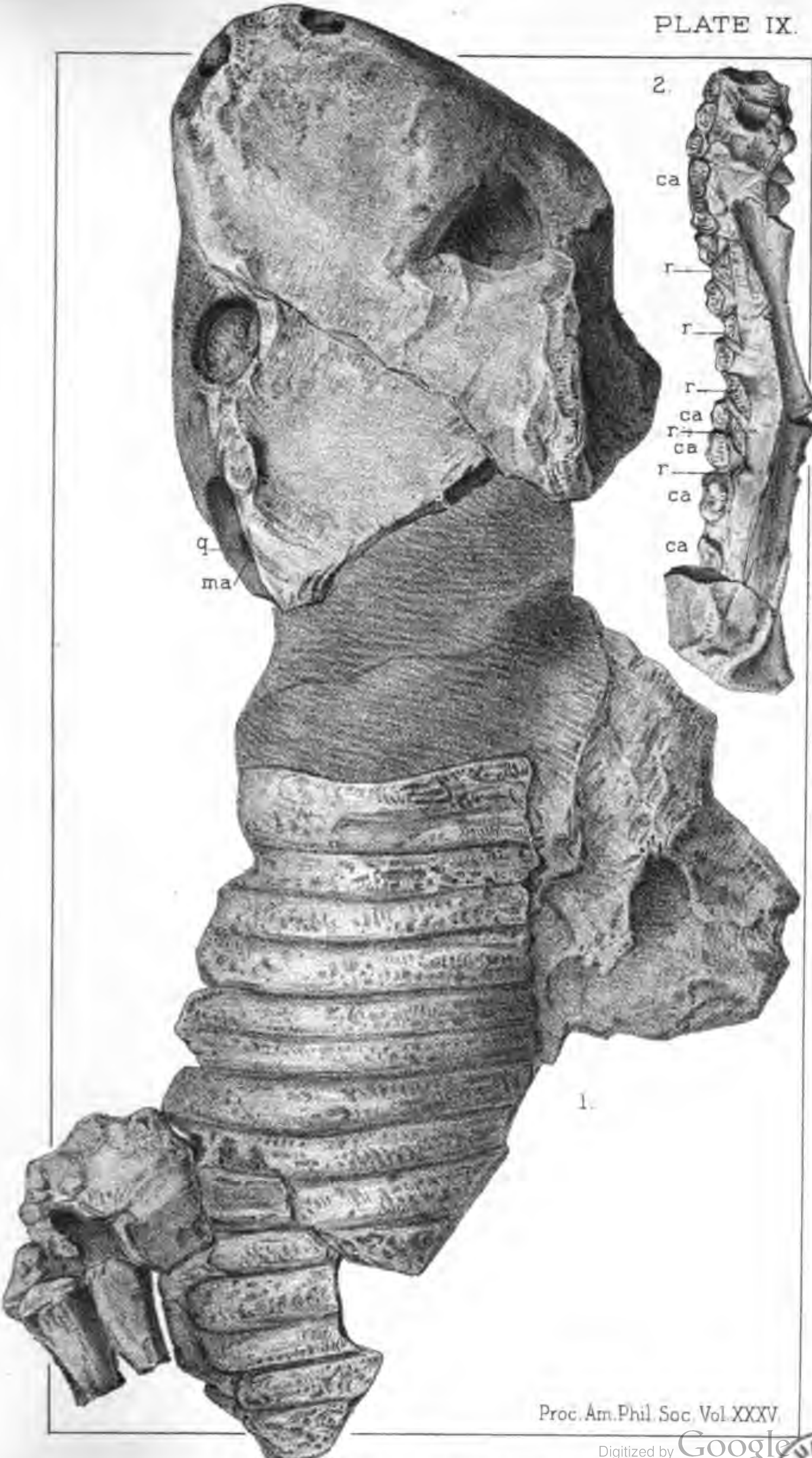
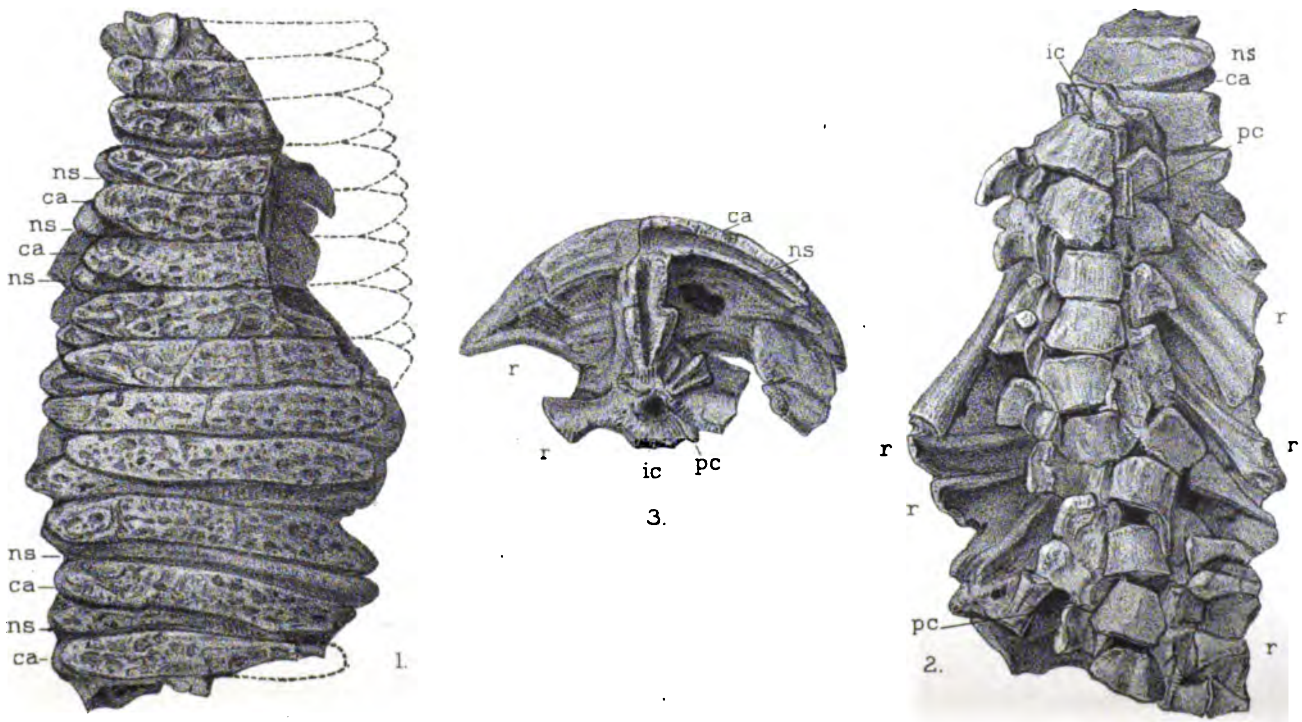


1. OTOCOELUS MIMETICUS COPE 3/5
2. O. TESTUDINEUS COPE 2/3

PLATE X.



DISSORHOPHUS ARTICULATUS COPE 5/6

PLATE X.

Dissorhophus articulatus Cope, *American Naturalist*, 1895, p. 998; portion of skeleton, five-sixths natural size.

Fig. 1. Carapace from above.

Fig. 2. Vertebral column ribs and carapace from below; same specimen as Fig. 1.

Fig. 3. Anterior extremity of same specimen.

Lettering.

Q., Quadrate bone; *Md.*, Mandible; *Pg.*, Pterygoid; *MA.*, Meatus auditorius externus; *Cl.*, Clavicle; *Es.*, Episternum; *Sc.*, Scapula; *Co.*, Coracoid; *Gl.*, Glenoid cavity; *H.*, Humerus; *Cu.*, Cubitus; *Ce.*, Centrum; *Ic.*, Intercentrum; *Pc.*, Pleurocentrum; *Ns.*, Neural spine; *R.*, Rib; *Ca.*, Carapace; *Fe.*, Femur; *T.*, Tibia; *Fi.*, Fibula.

Sixth Contribution to the Knowledge of the Marine Miocene Fauna of North America.

By E. D. Cope.

(Read before the American Philosophical Society, May 15, 1896.)

The fifth contribution was published in the PROCEEDINGS of the Society for 1895, p. 135, and the fourth in the same for 1870, p. 270.

SYLLOMUS CRISPATUS Cope, gen. et sp. nov.

Char. gen.—Order Testudinata; family probably Cheloniidæ. Costal bones developed beyond rib extremities, and uniting with marginals by suture. Surface sculptured with grooves and ridges. Humerus with entepicondylar foramen enclosed, and flattened shaft. Radial process remote from head.

This is the only definable form of Testudinata yet discovered in the Yorktown bed of the Chesapeake region. It is quite rare, as I have met with it at one time and place only. The carapace is more fully developed than in Chelone and Argillochelys, and it differs from these and from Lytoloma in the sculpture of the surface. From all of these genera and from Peritresius it differs in the union of the marginal bones with the costoids by suture.

A few fragments of a species of Lytoloma have been found in the same formation.

Char. specif.—This tortoise is known to me from two incomplete costal bones and a humerus. One costal fragment is distal, and the other is proximal. The humerus has the deltoid crest broken off at the base.

The carapacial bones are very thin and consist of a thicker superior

dense layer, a light spongy layer, and a very thin inferior dense layer. There were no horny scuta, and it is doubtful whether there were any dermal sutures. The surface is marked with numerous tubercles which are of elongate form, and run in various directions, frequently inosculating and separating generally narrow fossæ. They are finer and more nearly parallel on the distal part of the costal than on the proximal, and they turn at right-angles to the intercostal sutures. The proximal part of the costal is crossed by an angular keel which runs parallel to the middle line of the carapace. It is smooth, interrupting the sculpture. There are therefore two low parallel keels on the superior part of the plastron. Whether there is a median keel cannot be determined, as no vertebral bone is preserved. At one side of this keel (? proximad) is a smooth shallow groove, which may represent the border of a vertebral scutum. Not enough of it is preserved to demonstrate its nature.

The shaft of the humerus is flat in the plane of the distal extremity and is nearly straight, except that it bends a little downwards proximad of the distal extremity of the deltoid crest. The latter descends low on the shaft marking one-third the length. Its inferior portion is recurved inwards towards the head. The long axis of the head is at right angles to that of the shaft. The radial process is prominent, and marks two-fifths the length of the shaft from the head on the internal edge. The straight line of the axis of the humerus reaches the distal extremity between the condyles and the entepicondylar foramen. Thus the condyles are turned slightly ectad. The internal portion of the condyle has a greater anteroposterior diameter than the external, and though the articular surface is convex anteroposteriorly, transversely there are three shallow concavities, one external and two internal. The internal epicondyle is wide and flat, and equals the condyles in transverse diameter. The external epicondyle is little prominent. The entepicondylar canal is oblique, entering nearer the inner margin below, and issuing at about the middle above.

Measurements.		MM.
Proximal width of costal 1		47
Thickness of do. at margin		7
Width of costal 2, at distal end		60
Thickness of do. at distal margin		3
Length of humerus		100
Diameters of head	anteroposterior	32
	transverse	17
Width of humerus distally		41
Transverse extent of condyles		22
Length from radial process to distal end		53

I obtained the specimens above described from a Neocene bed on the Pamunky river, Virginia. It was associated with the *Mesocetus siphunculus* Cope, and various species of Platanistidæ, and a Squalodon.

Metopocetus durinasus, gen. et sp. nov.

Char. gen.—Lateral occipital crests continuous with anterior temporal crests which diverge forwards. Frontal bone elongate, not covered posteriorly by the maxillary, coössified with the nasals. Nasals short, coössified with each other, not projecting anterior to frontals.

Accompanying the cranial fragment on which this genus is founded is a piece of a premaxillary bone of appropriate size, which presents the character of that of a whalebone whale. The true position of this genus is probably between Cetotherium and Agorophius. It is probably a mysticete which approximates the ancestral zeuglodont type which is represented in our present knowledge by the genus Agorophius. It is connected with Cetotherium by the new genus Cephalotropis, which is described below. The three genera form a group, which may be properly referred to the Balænidæ, which is characterized by the elongation of the frontal and parietal bones on the superior walls of the skull. They differ as follows:

A temporal ridge; maxillaries little produced posteriorly; nasals not produced beyond frontal, coössified with the frontal and with each other.. *Metopocetus* Cope.

A temporal ridge; maxillaries much produced posteriorly; nasals free from frontals and from each other, produced well anteriorly........ *Cephalotropis* Cope

No temporal ridge; maxillaries much produced posteriorly; nasals free from frontals and from each other, well produced forwards......... *Cetotherium* Brandt.

The specimen on which the genus Metopocetus is founded is quite mature so that the sutures are coössified. The frontomaxillary and frontopremaxillary sutures are however distinct, as they appear to me, and they are remarkable for their position. They extend but little posterior to the external nareal openings. The latter are, in relation to the supraoccipital crest, anterior, but in relation to the position of the nasals, posterior. The nasals are short for a Balænid, although they enter wedge-like into the frontals for a considerable distance.

The position of the genera Metopocetus and Cephalotropis may be similar to that of the genera Ulias and Tretulias, which are known from mandibular rami only. One or both of the former may be identical with one or both of the latter; but of this there is as yet no evidence.

Char. specif.—The specimen which represents the *Metopocetus durinasus* is a cranium posterior to the nares, lacking the left exoccipital and squamosal regions, and the right zygomatic process. Both occipital condyles are preserved, and the basicranial region as far as the anterior nares.

The supraoccipital extends well forwards and its lateral crests present a moderate concavity outwards and forwards. Its apex is represented by a semicircular mass, posterior to which it is deeply concave, and the concavity is divided by a longitudinal median crest. The temporal

fossæ approach near together on the median line, forming a short sagittal crest, which is about as wide as it is long. From this the temporal ridges diverge abruptly, and these extend in a nearly straight line forwards, diverging from the line of the axis of the skull at an angle of about twenty-five degrees. Between it and the lateral occipital crest the temporal fossa is concave to the line of the anterior border of the squamosal bone. At the latter point the line of the suture presents an angle, which extends downwards, outwards and forwards. Between it and the posterior temporal crest the surface is concave above.

The exoccipital is flat vertically, and extends a little posterior to the transverse line of the occipital condyles. The postglenoid face of the squamosal is vertical, and it projects laterally beyond the exoccipital. The postglenoid crest is not conspicuous, and the glenoid cavity presents downwards, and very little forwards. The posterior temporal crest bounds a groove of the superior face of the part of the squamosal that lies posterior to it. The latter face is quite wide, and its external bounding angle is a right angle. It is continued as the superior face of the zygomatic process.

The petrous bone has a peculiar form. Its mastoid portion presents externally a nearly discoid outline between the exoccipital and squamosal. Its inferior portion descends as a process which forms the short stem of a half-tubular horizontal portion, which opens downwards and posteriorly, forming a partial meatus auditorius.

The lateral descending borders of the basioccipital are so prominent as to enclose a deep groove between them. The posterior nares are about opposite to the anterior border of the foramen lacerum.

The frontal region at its posterior apex is convex from side to side. As it widens it presents three subequal faces, two lateral and one median. The median plane is separated from the laterals by a shallow groove on each side, which become deeper anteriorly, and turn abruptly outwards at the nareal border. They appear to be the outlines of the nasal bones. Anteriorly the lateral planes become thickened longitudinally just external to these grooves. The entire anterior portion of the external planes is a sutural surface, with longitudinal grooves for a length averaging 40 mm. This surface can relate to nothing but the premaxillary and maxillary elements. This point of attachment is, however, anterior to that of any known genus of Mysticete; and is anterior to that in the *Agorophius pygmæus* Müll. In not extending so far posteriorly as the nasal bones, it leaves the frontals to embrace the latter anteriorly to an unusual extent. This is on the supposition that the indistinct grooves on each side of the middle line really represent the lateral borders of the nasal bones, which is not certain, except as to their anterior portions.

Measurements.	MM.
Width of skull at exoccipitals	406
" " " postglenoid angles	570

Measurements.	MM.
Width of occipital condyles	150
" foramen magnum	65
" sagittal crest	17
" anterior border of nasal bones	90
" skull at sagittal crest	170
" sphenoid at middle of for. lacerum	135
Anteroposterior diameter of glenoid surface	115
Length of nasal canal	250
" from occipital condyles to anterior nares	450
" " foramen magnum to posterior end of sagittal crest (oblique)	210
Length of sagittal crest	15
" from " to anterior nares	195

This specimen was obtained by Prof. Arthur Bibbins from a Miocene marl from near the mouth of the Potomac river, in Maryland. I am under much obligation to the Rev. John T. Goucher, President of the Woman's College, of Baltimore, for the opportunity of studying the specimen, which belongs to that institution.

CEPHALOTROPIS CORONATUS, gen. et sp. nov.

Char. gen.—Parietal bone separating supraoccipital and frontal by a considerable space and presenting a sagittal crest. Frontal extensively overlapped by the maxillaries, premaxillaries and nasals. Nasals elongate, distinct from the adjacent elements. Frontal presenting divergent temporal angles.

This genus differs from Cetotherium in the presence of temporal ridges or angles. It differs from Metopocetus in the free elongate nasal bones.

Char. specif.—The specimen which represents this species is a portion of the cranium which includes the elements which surround the brain except the occipital, the superior part of the latter remaining; together with the posterior parts of the maxillaries, premaxillaries and the greater part of the nasals, and the basisphenoid and presphenoid in part, and a considerable portion of the left temporal. The sutures distinguishing the several elements are distinct, so that the boundaries of the latter can be readily distinguished. In describing this fragment I will compare it especially with the *Metopocetus durinasus* and *Cetotherium megalophysum*, where the corresponding parts are preserved.

The supraoccipital angle is produced further anteriorly than in either of the species named, and the sagittal crest is longer than in either. The summit of the smooth occipital surface forms a transverse border, which cuts off the apex of the occiput, thus bounding posteriorly a triangular area, of which the sides are a little longer than the base. This triangle has a low, median keel, on each side of which the surface is

concave, and is marked with numerous irregular fossæ. The surface has been evidently the seat of the insertion of something; but whether it was entirely of a ligamentous character or whether some tegumentary structure had its basis there I do not know. The superior border of the temporal fossa is regularly concave towards the middle line, and regarding the sagittal crest as restricted to the parietal bone, its truncate edge is wider at the extremities than at the middle. The narrowest portion of the crest is nearer the frontoparietal than the parietoöccipital suture. The temporal ridge is in regular continuation of the edge of the sagittal crest, and becomes transverse in direction towards the orbital border of the frontal bone. This border is broken off.

The vertical temporoparietal suture does not run along a ridge as in the *M. durinasus*, but its superior portion is on a low, obtuse angle. The frontoparietal suture extends posteriorly from the sagittal crest downwards, much posterior to the direction it presents in the *C. megalophysum*, where its direction on each side is a trifle anterior to transverse. Across the front the suture is coarsely serrate, differing from the sutures of the anterior border of the frontal bone, which are closely and deeply interdigitate, as in the *C. megalophysum*. The superficial median part of the frontal is about one-third as long as the corresponding part of the parietal. The nasomaxillary suture with the frontal is short in the transverse direction, not reaching the temporal ridge on each side. The frontomaxillary suture then becomes nearly longitudinal for a distance of 50 mm. and then turns outwards for 25 mm. On the opposite side the posterior border of the maxillary is more oblique, and extends from the transverse median portion divergent from the line of the temporal ridge, forwards and outwards. The latter is probably the normal direction of the suture. The nasal bones are very narrow, but expand gradually anteriorly. They do not terminate posteriorly in an acute angle as they do in the *C. megalophysum* and *M. durinasus* (apparently), but are truncate. The premaxillaries are also narrow at this point. Their posterior extremities are broken off. The glenoid cavity presents downwards. The presphenoid is plane below anteroposteriorly and transversely posteriorly, but is slightly convex below anteriorly. It is hollow.

Measurements.	MM.
Length of supraoccipital triangle to occipitoparietal suture	80
Length of pariëtal on middle line	60
" frontal " " "	25
Width of supraoccipital at base of supraoccipital triangle	124
Width of base of cranium opposite supraoccipital triangle	115
" sagittal crest	18
" nasals at base	28
" " 140 mm. anterior to base	50

In the interstices of the specimen portions of matrix remain which have the color and character of the material of the Yorktown formation. Embedded in this at certain points are fragments of Mollusca of the genera Pecten, Lucina and Turritella. It was probably derived from the Chesapeake region. The fragment belongs to the museum of Johns Hopkins University, of Baltimore, and I am under many obligations to Prof. William B. Clark, State Geologist of Maryland, for the opportunity of studying it.

RHEGNOPSIS PALÆATLANTICUS Leidy. *Balæna palæatlantica, Proceeds. Academy Phila.*, 1851, p. 308. *Balænoptera palæatlantica* Cope, *Proceeds. Academy Phila.*, 1868, p. 193. *Protobalæna palæatlantica* Leidy, Extinct Mamm. Dakota, Nebraska, 1869, p. 440.

The typical and only specimen of this species is a fragment of a lower jaw from the Yorktown bed of S. E. Virginia. Its specific characters differ from those of other Balænidæ referred to in this and preceding papers by me, and it displays in addition a character which Leidy has described, and which is very conspicuous. That is, the presence of a Meckelian fissure, which extends deeply into the mandibular ramus. I agree with Leidy that this feature should be regarded as generic, and so define the genus as follows, under the name Rhegnopsis. Roof of dental canal perforated by gingival tubes; a Meckelian fissure. Dr. Leidy's name Protobalæna is preoccupied by Van Beneden (1867).

CETOTHERIUM LEPTOCENTRUM. *Eschrichtius leptocentrus* Cope, *Proceeds. Academy Phila.*, 1867, p. 147. *Cetotherium leptocentrum* Cope, *American Naturalist*, 1890, p. 616. *Cetotherium crassangulum* Cope, *Proceeds. American Philosophical Society* 1895, p. 148.

After the latest description of this species was published I visited the locality at which it was discovered, in company with Prof. Arthur Bibbins, of Baltimore. I found a part of a mandibular ramus which coincides in all respects so closely with the portions which are still adherent to the skull that I have no doubt that they pertain to the same species, and probably to the same individual. One character in which this fragment agrees with the other portions of the rami is the presence of coarse cancellous bony tissue throughout the gingival dental canal. This reduces the diameter of the latter to that of the large external gingival canals. The form of the middle part of the ramus as indicated by the fragment is very different from that of any other whalebone whale known to me. The internal face is nearly flat and vertical, while the external face is convex only at the superior portion. For a short distance exterior to the superior angle it is subhorizontal; it then gradually decurves, and is then entirely flat to the inferior subacute edge. The section is then subtriangular, with the base superior and the apex inferior. The interior gingival foramina continue very small, and they are not connected by a groove. Distance between two of them,

45 mm. The external foramina are quite large; distance between two of them, 165 mm.

A third cervical vertebra was picked up on the James River, Virginia, by Prof. Bibbins, a few miles below the locality from which the type specimen of the *C. crassangulum* was derived, and kindly presented by him to me. It belongs to an adult animal, and considerable parts of one of the parapophyses and neurapophyses are preserved. The former are directed downwards at an angle of about 25°, and therefore much less steeply than in the *C. cephalus*. The form of the centrum is a transverse parallelogram and therefore similar to that of the two individuals previously described. The diameters are: transverse below middle 140 mm.; vertical 97 mm.; anteroposterior at base 34 mm. The dimensions, while less than those of the type *C. crassangulum*, are appropriate to a smaller individual of that species.

EXPLANATION OF PLATES.

Plate XI.

Fragmentary crania of Balænidæ of the Yorktown epoch, one-sixth natural size.

Fig. 1. *Cetotherium megalophysum* Cope, from above. Coll. Johns Hopkins University.

Fig. 2. *Cephalotropis coronatus* Cope, from above. Coll. Johns Hopkins University.

Fig. 3. *Metopocetus durinasus* Cope, from above. Coll. Woman's College, Baltimore.

Plate XII.

Diagrams of sections from near the middle of the mandibular rami of extinct Balænidæ, one-half natural size.

Fig. 1. *Cetotherium leptocentrum* Cope; Virginia.

Fig. 2. *Cetotherium cephalus* Cope; Maryland; section proximad of the middle.

Fig. 3. *Cetotherium cephalus* Cope, same jaw as Fig. 2, distad of the middle.

Fig. 4. *Cetotherium davidsonii* Cope; California.

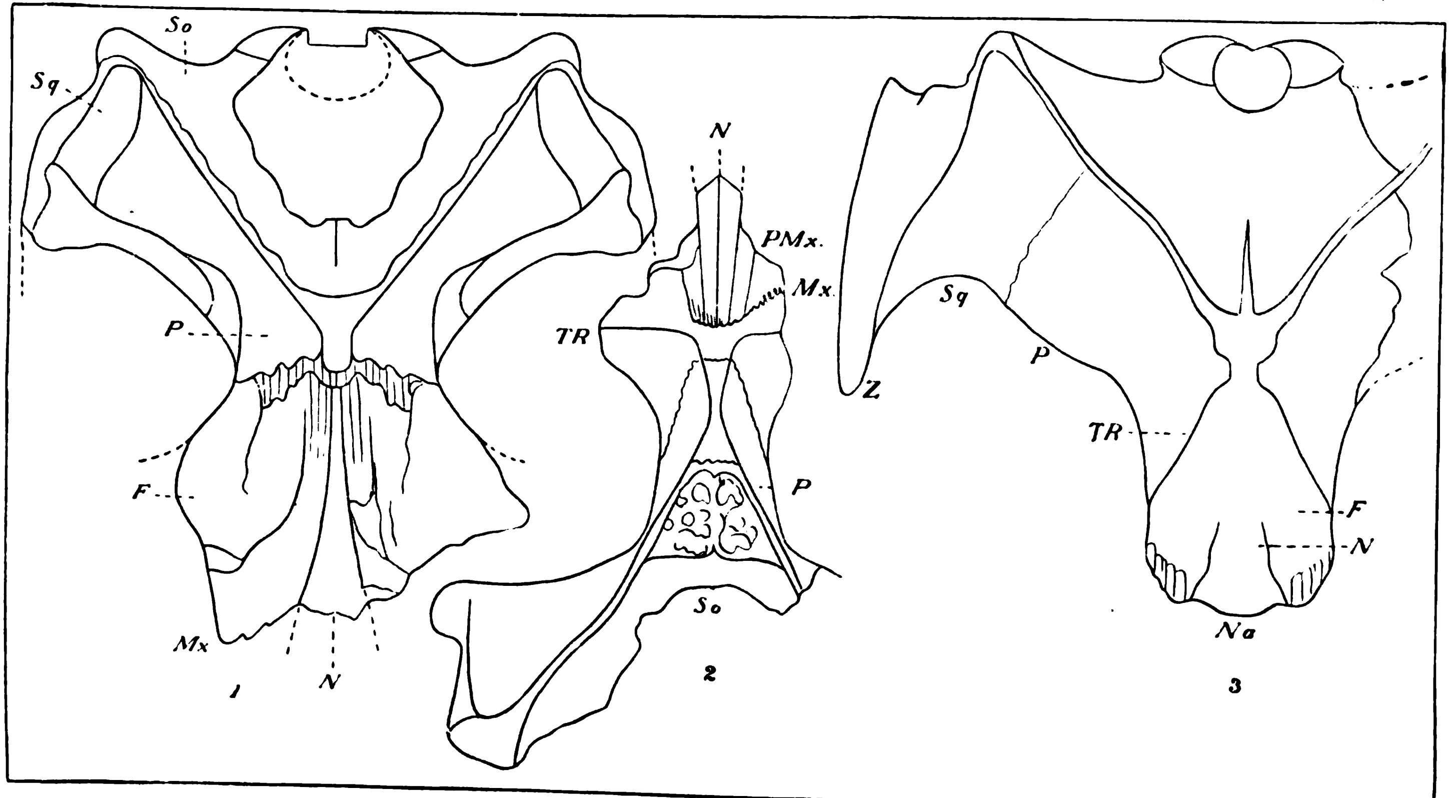
Fig. 5. *Rhegnopsis palæatlanticus* Leidy; Virginia.

Fig. 6. *Mesocetus siphunculus* Cope; Virginia.

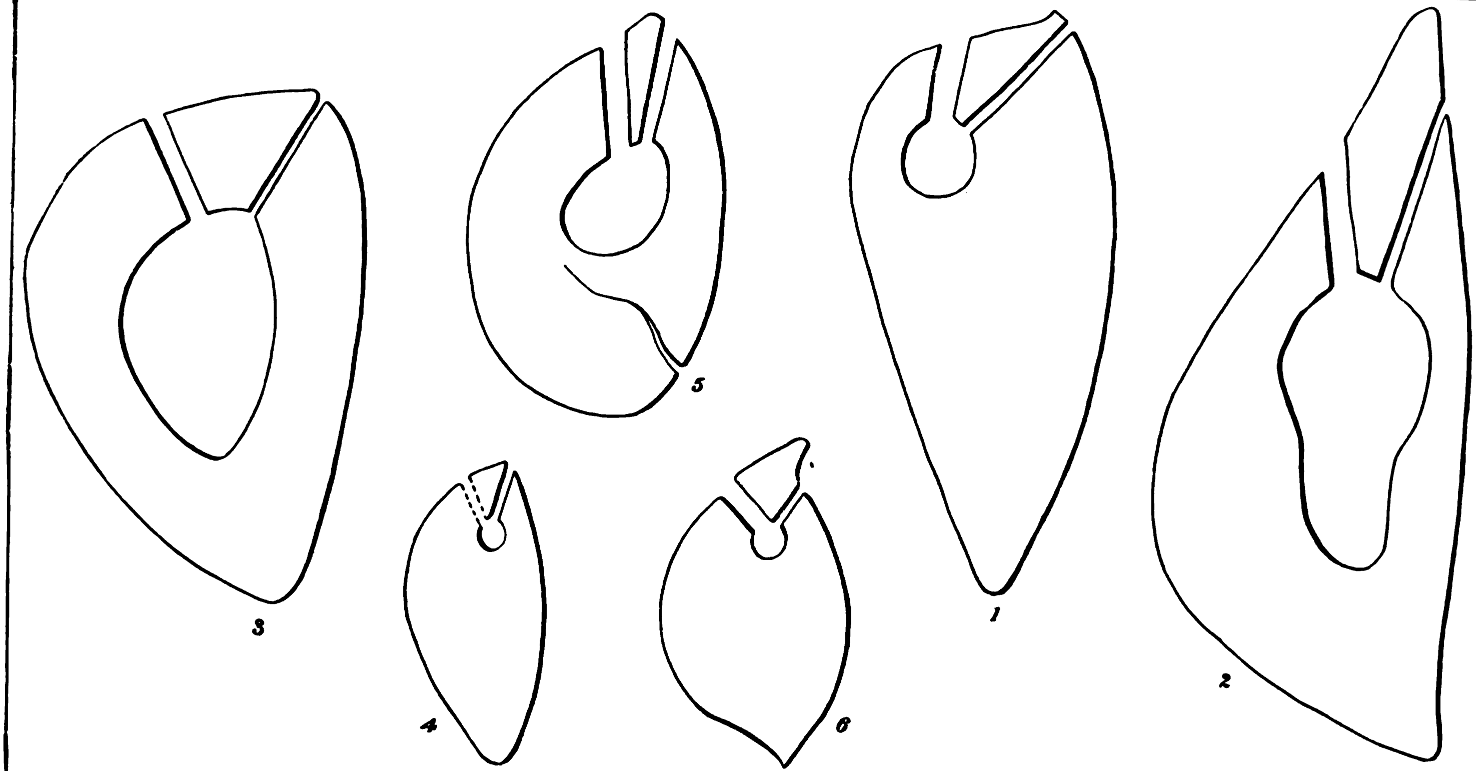
No. 1, Coll. Woman's College, Baltimore; 2, 3, 4, 5, Coll. Academy Natural Sciences, Philadelphia; 6, Coll. E. D. Cope.

Lettering.

So., Supraoccipital bone; *Sq.*, Squamosal; *Z.*, Zygomatic; *P.*, Parietal; *F.*, Frontal; *N.*, Nasal; *Na.*, External Nares; *Mx.*, Maxillary; *Pmx.*, Premaxillary; *T. R.*, Temporal Ridge.



1. *Cetotherium.* 2 *Cephalotropis.* 3. *Metopocetus.*



1–4. *Cetotherium.* 5. *Rhegnopsis.* 6. *Mesocetus.*

Notes on the Osteology of the White River Horses.

By Marcus S. Farr.

(Read before the American Philosophical Society, May 15, 1896.)

MESOHIPPUS.

Although nearly half a century has elapsed since *Mesohippus bairdi* was first described by Leidy,* our knowledge of its osteology has remained comparatively incomplete, all the known material being limited to foot bones and more or less complete skulls. Most all of the skeletons that were found were badly broken up and only the larger and more perfect bones were saved. Modern methods of collecting, essentially those introduced by Mr. J. B. Hatcher,† have revolutionized all this and now even the most delicate bones, though badly broken up, are preserved as easily as the large bones were before collecting was done in a scientific manner.

Fortunate discoveries of more complete skeletons during the last three years have given us very much better material and now enable us to supplement the accounts of *M. bairdi* that have already been given, to add many new points on the osteology of the species and to offer a restoration which is an improvement on those heretofore offered.

Several species of Mesohippus have already been made on material from Nebraska, Dakota and Colorado. These have either been founded on a few teeth presenting peculiarities or on foot bones not associated with teeth. These species have not been generally accepted, and the founding of species on such limited material especially in such a genus as Mesohippus which presents such a marked degree of individual variation does not seem justifiable and merely burdens science with useless synonyms. I have not seen the types upon which the various species, *M. exoletum,*‡ *M. agrestis,*§ *M. cuneatus,*‖ *M. celer,*¶ etc., have been established, but from the study of the individual variations in the many** specimens of *M. bairdi* studied by the writer it seems very evident that the species are not well grounded and that the peculiarities may be accounted for by the factor already mentioned.

The discovery of the Protoceras beds and their recognition as a distinct subdivision of the White River formations†† marks a stage in the development of the palæontology of this epoch.

* Leidy first described this species as *Palæotherium bairdi*, *Proc. Acad. Nat. Sci.*, 1850, p. 122.

† Curator of Vertebrate Palæontology in the College of New Jersey.

‡ Cope, *U. S. Geol. Survey of the Territories*, 1873.

§ Leidy, *Rept. U. S. Geol. Sur. Terrs.* (4to), i, p. 251, Pl. vii.

‖ Cope, *Palæontl. Bull.*, No. 16, p. 7, August 20, 1873.

¶ Marsh, *Am. Jour. Sci. and Arts*, 1874, p. 251.

** Remains of nearly one hundred individuals have been studied by the writer.

†† Wortman, *On the Divisions of the White River*, *Bull. Am. Mus. Nat. Hist.*, Vol. v, pp. 95–106.

The fauna of the Protoceras beds is unique in many ways, especially in the number of new and bizarre forms that come in, some evidently by migration, while others are the direct descendants of the species of the underlying Oreodon beds.

These strata are interesting, as they form a transition to the later John Day beds, their fauna being intermediate between the latter and that of the Oreodon beds.

A new species of horse has been found in this formation which helps very greatly in explaining the individual variations of *M. bairdi*, as many of these are seen to be attempts in the direction of *M. intermedius*, which is undoubtedly the direct descendant of the former. Besides these two species which are seen to stand in the direct relation of ancestor and descendant there is another species, *M. copei*, which occurs first in the strata of the Oreodon beds and is represented in the Protoceras beds by larger individuals.

Geological succession of the species:

Protoceras beds: *M. bairdi, M. copei, M. intermedius.*

Oreodon beds: *M. bairdi, M. copei.*

Titanotherium beds: *M. bairdi.*

The genus Mesohippus occurs then in all the different horizons of the White River beds. In the Titanotherium beds it is usually represented only by fragmentary remains, which, however, are unmistakably those of *M. bairdi.*

The Oreodon beds have yielded most of the best material. Through the whole extent of the fossiliferous strata of these beds, a vertical thickness of at least one hundred and eighty feet, remains of *M. bairdi* are fairly abundant. However, the remains are not well preserved, groups of teeth and the larger limb bones are common, while well-preserved portions of the skeleton are rare—a perfect skull has never yet been found. Beside *M. bairdi* we get in the upper Oreodon beds a new species which has been described as *M. copei.** The Protoceras beds have yielded only fragmentary remains of *M. bairdi.* This species does not represent the main line of descent during this epoch, but it is here taken up by *M. intermedius* while the former still persists as a side line. We also get *M. copei*, which continues on from the Oreodon beds and is now represented by larger individuals.

Of *M. bairdi* nearly the entire skeleton is represented by material in the Princeton collection.

The skull has been quite fully described by Leidy,† and the skeleton has been the subject of an exhaustive paper by Prof. Scott,‡ but when this paper was written the entire skeleton had not yet been found and the incisor teeth of upper series are the result of explorations of the summers of 1894 and 1895, so some points in the description will be new.

*Osborn and Wortman, *Bull. Am. Mus.*, Vol. vii, pp. 356–358.

† *The Extinct Mammalian Fauna of Dakota and Nebraska*, Philadelphia, 1869.

‡ *Journ. of Morphology*, Vol. v, No. 3, December, 1891.

Moreover the description of this species *de novo* is justifiable because we wish to trace the steps in the evolution of the horse as they can be followed in the horizons of the White River strata and must therefore have a description of one species as a standard for comparison.

It is the purpose of this paper to add some new points on the osteology of *M. bairdi* and to give a new, more accurate and more complete restoration ; to give a short description of *M. intermedius* and *M. copei*, and to show their relation to each other and to *M. bairdi*.

I must acknowledge my very great indebtedness to Prof. Scott, who has given me so much assistance in the way of suggestion and criticism and whose kindly interest in my work has ever been an inspiration during my three years of graduate study in Princeton. To Mr. J. B. Hatcher I am also very much indebted for free access to collections and for kindly criticism and help and for much information on White River mammals.

I must also extend my thanks to Prof. H. F. Osborn and Dr. J. L. Wortman, of the American Museum, for permission to study some of their very beautiful material ; also to the latter for valuable suggestions.

The drawings are by Mr. R. Weber, and add materially to the value of the paper.

The Dentition

The dental formula is I. $\frac{3}{3}$, C. $\frac{1}{1}$, Pm. $\frac{4}{4}$, M. $\frac{3}{3}$. The dentition is thus seen to be unreduced, and the specialization or modernization consists in the complexity of the last three premolars which are molariform and Pm. 2 is beginning to assume the elongate character, so marked in the living horse by the elongation of the anterior part of the external half of the tooth. The characters of the permanent teeth have already been described by Leidy,* Osborn,† and Scott,‡ but very little has been written concerning the milk dentition and the superior incisors have only very recently been found. Only two skulls are known bearing the upper incisors, nearly all the skulls that are discovered having the end of the very narrow snout broken off.

The inferior canine is the smallest of all the teeth ; it is suberect and conical, and there is a wide diastema between it and Pm. 1. The lower incisors are spatulate or chisel shaped and do not show any indication of a depression or pit. They have sharp cutting edges, and their inner surfaces are strongly concave. The first incisor is the longest (*i. e.*, highest above alveolar border) and also the widest of the incisor series. I. 2 is smaller than I. 1, while I. 3 is the smallest of the incisor series. There is thus a decrease in size and length of incisors outwardly towards the canine. The six incisors form an unbroken row.

* *Ancient Fauna of Nebraska*, pp. 70, 71 ; *Extinct Mam. Fauna of Dak. and Neb.*, pp. 305–309, 1869.

† *Bull. of Mus. of Comp. Zoöl.*, Vol. xvi, pp. 88, 89.

‡ "Osteology of Mesohippus and Leptomeryx," *Journ. of Morph.*, Vol. v, No. 3, pp. 303–305.

The anterior border of the mandible is rounded and the teeth are arranged in the segment of a circle.

The fourth lower premolar is wider transversely than any of the other teeth, while the posterior half of Pm. 3 is wider proportionately than any of the remaining teeth, with the exception of the former. Pm. 4 has a massiveness not seen in the other lower teeth. Sometimes this is so marked that if the teeth were not found together they would in all probability be attributed to a larger individual. It had long been supposed that the superior incisors were not pitted. Prof. Scott * has separated Mesohippus from Miohippus on the character of the upper incisors. A skull in the Princeton collection shows the upper incisors which seem to be pitted, but as they are so much worn a determination of their character is not possible. Osborn and Wortman † have just described these teeth and through the kindness of these gentlemen I have been permitted to examine this beautifully preserved skull. The two outer pairs of incisors show a distinct invagination, which is not, however, present on I. 1. Upper Pm. 1 is a small single-coned tooth, which has two distinct roots. The cingulum is well-developed on the inner side, enclosing a deep pocket. Anteriorly there is a tiny accessory conule. The corresponding tooth of the lower jaw is very small and inserted by only a single fang. Pm. 4 of the upper series is wider transversely than any of the other teeth.

Succession of the Teeth.

From all that can be observed the three large deciduous molars first appear simultaneously in both jaws. The next tooth to appear is that which represents Pm. 1 of the permanent set. Nothing is known as to the time of appearance of the incisors and canines, but judging from analogy we may presume that they appear as early as the milk molars. A mandible of Mesohippus (No. 11107), with milk dentition and M. 1 of the permanent set, shows alveoli for the three incisors and canine. The next tooth to appear (after persistent Pm. 1) is M. 1, which is succeeded by M. 2. Next the temporary molars are replaced by the permanent premolars.

In the upper jaw these are replaced in the following order: Pm. 4, Pm. 3, Pm. 2 (Pm. 1 persisting in both jaws). One specimen shows Pm. 4 almost ready to erupt, while Pm. 3 is very much smaller and the germ of Pm. 2 is very feebly developed. The mode of succession in the lower jaw seems to follow the same order. In specimen No. 10995, M. 1 and M. 2 have appeared, and the germs of the permanent teeth are seen by picking away the bone and exposing roots of teeth, where the germ of Pm. 4 is seen to be better developed than that of Pm. 3. This also accords with the rate

* *Trans. Amer. Phil. Soc.*, 1883, p. 79. In the light of present knowledge it seems best to abandon the genus Miohippus and to make the genus Mesohippus include the John Day equines as well as the White River forms.

† *Bull. Am. Mus. Nat. Hist.*, Vol. vii, p. 353.

of wear of teeth, as Pm. 4 is usually more worn by attrition than Pm. 3. After the deciduous teeth are replaced by those of the permanent set, M. 3 appears in both jaws.

It is not possible to tell from available material whether the incisors and canines are replaced or are persistent. In the later horse from the Equus beds, the incisors were certainly replaced, and the germ of canine is seen piercing the jaw. The foramen, through which it is growing, is large, but it is not possible to determine whether it had a predecessor or represents a permanent canine which does not appear until the other teeth are developed. Chauveau* makes the statement that the canine persists and is not replaced in the horse. However, judging from analogy, we are quite safe in presuming that in *M. bairdi* both the incisors and canines had predecessors in the milk series.

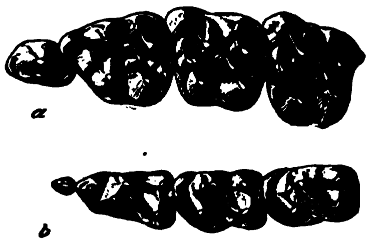
The Milk Dentition.

The temporary dentition may be given in the following formula:

I. $\frac{3}{3}$, C. $\frac{1}{1}$, D. $\frac{4}{4}$. See Fig. 1.

The tooth which represents Pm. 1 of the adult skull is not a true milk tooth, as it does not appear until the other teeth of the milk set are fully developed, and is not replaced as are the teeth of the temporary series. It may be considered a persistent milk tooth, as it has no predecessor, and then the dental formula will be as given above. If considered one of the permanent set, as there are ample reasons for doing, the molar formula will be: D. $\frac{3}{3}$.

Fig. 1.



Milk Molars of M. bairdi, $\frac{1}{1}$.
a, superior series.
b, inferior series.

The differences between the deciduous teeth and those of the permanent set are not due to any addition or reduction in the number of elements entering into the formation of the teeth, but are due to the difference in the relative development of the elements in the two sets. The differences can best be described by instituting a comparison between the two sets, and to do this it will be best to describe those of the permanent set and then show how the deciduous molars differ from them. The last two of the temporary set differ only in minute detail from the corresponding teeth of the later set, but there is a fundamental difference between Pm. 2 of the permanent set and its predecessor in the milk series.

All of the premolar teeth, with the single exception of Pm. 1, are molariform. Pm. 2 of both jaws presents some points of difference

* *Comparative Anatomy of the Domesticated Animals.*

from the other teeth, while the simple character of Pm. 1 has already been sufficiently commented upon. The last lower molar, as in so many forms, differs from the others in the presence of an additional less well-developed lobe situated posteriorly. The lower molars and Pms. 3 and 4 have oblong, quadrate crowns, with an outer pair of fore and aft principal lobes, and an inner pair of secondary lobes connate with them. "The principal lobes of the crown are slightly oblique in their relative position, angularly convex and sloping externally, concavely excavated internally and are acutely crescentoid at their summit. Of the inner secondary lobes, the anterior is much the larger, and is pyramidal in form with a twin pointed summit." This character is observable only in teeth that are not worn excessively and disappears as the summits of the crown are worn off in mastication. "The antero-internal cusp springs from the crown at the conjunction of the principal lobes and is continuous with their contiguous crowns. The posterior of the secondary lobes is conical and springs from the crown in conjunction with the back horn of the posterior principal lobe. The front horn of the anterior principal lobe curves inward, downward and backward to the base internally of the anterior secondary lobe. A basal ridge (or cingulum) nearly continuous bounds the crowns of the lower molars externally. Posteriorly it rises inward and terminates in a tubercle springing from the conjunction of the two posterior lobes." Pm. 2 deserves a slight mention in passing. In the lower jaw the posterior half of this tooth is an exact copy of the corresponding part of any of the succeeding premolars or molars. One half of the antero-internal lobe is present as usual, but this alone forms all of what corresponds to this lobe in the succeeding teeth. Anterior to this and externally there is another lobe more nearly median in position. This is connected with the former by a ridge and the two together form a lobe which is very different from any of the others. Anterior to this and connate with it is a small lobe on the internal surface of the tooth. The deciduous tooth differs from the permanent one in that in the former the two anterior lobes are more distinct from each other and from the other lobes, so that we seem to have five lobes in this tooth. Again in the earlier set this tooth has a greater antero-posterior extent than any of the other teeth, almost equaling in length M. 3 of the permanent set, which has the additional lobe. In the permanent set Pm. 2 is even shorter antero-posteriorly than the succeeding tooth in the premolar series. In the milk set D. 4 has the posterior half narrower than the anterior half. In D. 3 both halves of tooth are of approximately the same width, while, in the permanent premolar series the posterior half of the tooth is always the wider, while in the molar series the reverse condition obtains. The cingulum is not so well developed on the deciduous molars as on the corresponding teeth of the permanent set. It is not developed on the external surface of the posterior lobe as in the permanent tooth, but is present on the posterior border of tooth where it ends in a tubercle. The cingulum

is well developed on the antero-external lobe of Ds. 3 and 4, even better than on the corresponding permanent tooth. It has lately been called to my attention that the cingulum varies in the individual with the nourishment, well-nourished individuals having it better developed than those poorly nourished, but the recurrence in many individuals of the character as given above precludes the possibility of its being an individual variation. The antero-internal cusp is wider antero-posteriorly in the temporary teeth than in the permanent set and the bifid character of this cusp is more marked in the former. All the lower milk teeth are narrower and longer antero-posteriorly than the permanent teeth. Both the upper and lower molars of the deciduous set are of not nearly so great vertical length as those of the later series.

The Upper Molars.

Premolars 2, 3 and 4 are molariform and Pm. 2 is beginning to assume the elongate character which is so much emphasized in the living horse. The six molars (*i. e.*, molars and molariform premolars) are nearly alike in size and form. "They have square crowns, wider transversely than broad antero-posteriorly and both these measurements greatly exceed the length. The crowns consist of three pairs of lobes—an outer and an inner pair of principal lobes and a much smaller pair situated between them, the secondary or accessory lobes. The outer lobes are demi-conoidal and form at their junction a narrow buttress externally. A stronger buttress bounds the fore part of the anterior of the two lobes. A tendency to the development of a buttress is seen also at the back part of the posterior of these lobes. The buttresses expand and are conjoined at the bottom of the crown, forming together a pair of arches bounding the external surfaces of the outer lobes. These surfaces are nearly flat and are divided by a conspicuous median ridge. The inner surfaces of the outer lobes are prominently or almost angularly convex. The inner lobes of the crown are simply conical, wider transversely than fore and aft and with the anterior slightly larger than the posterior. The median lobes are not more than half the size of the principal ones and appear as prominent folds curving outwardly from the inner lobes to the anterior face of the outer lobes. Elements of a basal ridge exist at the fore and aft parts of the crown and at the outlet of the valley separating the inner lobes. In the interval posteriorly between the back inner and outer lobes there exists a tubercle which in association with the contiguous portions of the basal ridge assumes the dignity of a sublobe." In Pm. 1 the anterior buttress is more distinct or separate than in the other molars, though it is not so large. The anterior of the median cusps is larger than the posterior, except in Pm. 2, which is peculiar in this as in so many other respects.

The teeth of the temporary set present the following differences from those of the permanent set described above:

1. The cusp situated between the outer and inner posterior lobes, the

so-called hypostyle, is less well developed in the deciduous molars than in those of the permanent set.

2. D. 2 is much larger, more elongate antero-posteriorly, more complex, the antero-external buttress being much larger and more distinct in the earlier set. It is so large that it might almost be considered a fifth principal lobe.

3. The median accessory lobes (5 and 6) are more conical than in the permanent set, where they are somewhat appressed. These lobes in the early set are separated by a distinct notch from the internal lobes.

4. The transverse ridges are more nearly confluent with the outer wall of tooth in most of specimens in the temporary set. There is, however, great individual variation in regard to this character.

5. In the adult skull all the molars and molariform premolars are much wider transversely than antero-posteriorly. The deciduous teeth are more nearly square, the two diameters being subequal.

6. The buttress on the antero-external lobe of tooth, the parastyle, is better developed in the milk set.

7. D. 2 is the longest tooth of the milk series and is beginning to assume the elongate character of this tooth in the modern horse, while the corresponding tooth of the permanent set is smaller than any of the other molar teeth.

8. All the temporary teeth are shorter in vertical height than those of the permanent set.

The Vertebral Column.

The cervical and dorsal vertebræ have already been minutely described. The lumbar vertebræ are almost certainly five in number. The centra are large and are reniform in shape, being wide transversely and not having the more nearly circular outline of the median dorsal vertebræ. All of the lumbars, with the exception of the last, have their centra strongly keeled. The centra are moderately opisthocœlous. The interlocking character of the vertebræ through the zygapophyses is marked. The neural spines are long, transversely compressed and narrow and have considerable antero-posterior extent. They are all directed forward at an angle. The transverse processes are well developed and widely expanded. The intervertebral foramina perforate the bases of the neural arches, and are not merely notches in the ends of the neural arch as they are in the anterior vertebræ of the column. The last two lumbar vertebræ have their transverse processes expanded almost as widely as those of the first sacral itself, and the transverse processes of the fourth lumbar abut against those of the fifth, while the latter bears on the posterior surface of the transverse processes deep concavities for the corresponding surfaces of the anterior end of sacrum. An analogous condition is seen in Equus, and in old individuals the last two lumbars are very frequently immovably coössified. The last lumbar has the spine more nearly erect than that of the penultimate lumbar vertebra.

A very remarkable character of the lumbar vertebræ is that they have spines which are nearly, if not quite, as high as those of the anterior dorsal region, which in the horse are so much elongated. In the latter the lumbars have spines which are lower, more nearly erect, of more considerable antero-posterior extent proportionately and are much less compressed transversely.

The Sacrum.

The sacrum of *M. bairdi*, as in most of the Ungulata, consists of one broad vertebra joining the ilia, followed by a series of narrower ones, gradually diminishing in width anchylosed to it behind. These latter diminish in width very gradually. In living Ungulates the number of vertebræ entering into the formation of the sacrum varies with the age of the individual and also varies in individuals of the same age.

Fig. 2.

Sacrum of M. bairdi, $\frac{1}{3}$.
Inferior view.

In the specimen which belongs with the pelvis described below there are six vertebræ. This is the most perfect sacrum of *M. bairdi* yet found, and the component vertebræ are fortunately well preserved and hardly crushed at all (see Fig. 2 and Plate xiii).

The first or true sacral vertebra is greatly expanded transversely and bears large articular surfaces for the ilia.

Anteriorly there are large convex facets which fit into the corresponding concavities in the transverse processes of the last lumbar vertebra. The first sacral has a low and comparatively wide centrum. The spine is very high, very much compressed laterally, as are all the spinous processes of the vertebræ, and is directed strongly forward, while in the modern horse it is almost vertical. The five succeeding vertebræ have transverse processes which are not so widely expanded, the centra are very much depressed and the neural arches are low and gradually decrease in height posteriorly. This, of course, conditions the size of the neural canal, which in this region is very much attenuated. The expanded transverse processes of the contiguous vertebræ are all united, so that they form a narrow elongate plate. The spine of the second sacral is gone, but the others are all preserved. That of the third is almost vertical, while the spines of the three posterior sacrals all slope backward at a decided angle. There is thus a very abrupt transition in the direction of the inclination of the spines from the first in which the spine projects forward to three in which the process is almost vertical. The plate formed by the anchylosis of the centra and transverse processes of the vertebræ is concave inferiorly or curves downward posterior to first sacral. The sacrum presents inferiorly the foramina for the five pairs of sacral

nerves, the inferior sacral foramina, while above we also find laterally between the neural arches of the contiguous vertebræ the five pairs of the superior sacral foramina.

Measurements of the Sacrum.	MM.
Length	116
Extreme width	64
Width third sacral	23
Width fourth do.	21.5
Width fifth do.	20

The Caudals.

The few caudal vertebræ preserved are sufficient to give us a general idea of the character of the tail. The first caudal has very widely expanded transverse processes similar to those of the posterior sacral region; the centrum is oval and the neural arches arise at a very great angle enclosing a high and very narrow neural canal. The transverse processes are of considerable antero-posterior extent, but do not equal the length of the centrum in width as they do in the posterior vertebræ of the sacral region. It is not possible to determine how many of the caudal vertebræ had complete arches, because of incomplete material. In Equus* the spine of the neural arch is bifid in the second caudal and the arches are incomplete on the third. The transverse processes gradually become shorter, the neural arches more rudimentary and are finally lost, and all we have is a cylinder of bone with very rudimentary processes which gradually diminish in size. Among the caudals preserved is one of these last, in which all the processes are very feebly developed. All the vertebræ of the tail are in general like those of the horse, and in them, as in most all of the anatomical features, we see a foreshadowing of what the future horse is going to be.

The Sternum.

With the almost complete skeleton figured in the restoration of *M. bairdi* in Plate xiii are preserved three segments of the sternum. These are the xiphisternum and two segments of the mesosternum. The former is very much more elongate and not so high as the other divisions of the sternum. Anteriorly it is about twice as broad as high, while posteriorly it is very much flattened. The free border is thin and rounded with irregular surface, showing where cartilage was attached. Laterally the body of this segment as of all the other is concave. The superior border is almost plane, while the inferior is slightly concave, or the free end may be said to project slightly downward.

The next segment in front of the above that is preserved is very evidently the penultimate segment of the mesosternum. This is very different in shape from the xiphisternum. The posterior portion is wide and

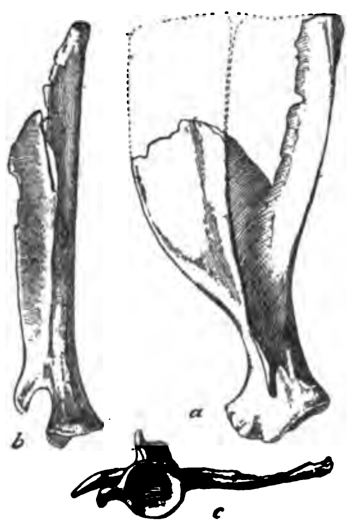
* No. 33?, Princeton Coll.

low, while anteriorly it is much narrower and higher. Both superior and inferior surfaces are plane and the sides are very strongly concave. The third segment is evidently the first division of the mesosternum, and is high and long and almost trihedral in cross-section. These separate segments of the sternum are not coössified, and the surfaces for the articulation of the sternal cartilages of ribs are not well shown. From the portions of sternum described above we are safe in assuming that there were at least six segments in the sternum of *M. bairdi*.

THE SCAPULA.

The nearly complete skeleton from which the restoration given herewith is made fortunately has the scapula very well preserved, and this reveals quite an unexpected character, viz., the presence of a distinct acromion. The only other Perissodactyl known to have retained this process is Pachynolophus (Orohippus) of the Bridger Eocene. Marsh * has described it in this genus as follows: "The scapula has a prominent acromial process, which is compressed and decurved as in some Carnivora." Mesohippus is the only Perissodactyl known to have retained this process until Oligocene times, and it has thus been retained longer by the horses than by any other family of this order. It is possible that future discoveries may also reveal the presence of a clavicle in Mesohippus, as it has been discovered in the contemporary *Oreodon culbertsoni*,† and in the latter genus it persists until Deep River times, where it has been found by Prof. Scott ‡ in the form which he has called Mesoreodon. The possession by both Mesohippus and Pachynolophus of this process would seem to justify us in regarding the latter as the Bridger ancestor of the horse line of which Mesohippus is the White River representative. The scapula is wider in proportion to its height than that of Equus. The anterior margin is very thin and strongly

Fig. 3.



SCAPULA OF M. BAIRDI, ⅔.
a, from outside.
b, from behind.
c, from below.

* *Amer. Jour. Sc. and Arts*, Series 3, Vol vii, 1874, p. 247

† A specimen in the museum of the University of Chicago reveals the presence of the clavicle.

‡ *Trans. Amer. Philos. Soc.*, Vol. xvii, p. 136.

convex, while the posterior border is only slightly rounded and is very much thickened, a character that has been retained by the Equidæ, Tylopoda, Pecora and Suina, but has been lost in the Tapiridæ and Rhinocerotidæ. The spine of the scapula is very high and seems to extend nearly or quite to the vertebral border. It is much nearer to the anterior border than the posterior, thus making the prescapular fossa much smaller than the postscapular.

The spine becomes gradually more prominent towards the middle portion, at which point it seems to have been highest and the edge was here strongly retroverted as in Tapirus and Rhinoceros. From this point it decreases in height towards the vertebral border.

The acromion is styliform in shape, is compressed antero-posteriorly and extends outward and downward, but does not quite reach the level of the glenoid cavity. It resembles in shape that of the camel and llama, but differs from these in that they are more slender, more nearly perpendicular and extend nearly or quite to the level of the glenoid cavity. The process gradually tapers towards the free end, which is somewhat rounded. The neck of the scapula is very much constricted and is comparatively long. The glenoid cavity is quite deeply excavated, is very slightly elongate antero-posteriorly and has a well-defined rim.

The coracoid process is strong, curves inwardly and is slightly retroverted.

Measurements of Scapula.	MM.
1. Extreme length	136
2. Width of neck	18
3. Width of distal end	32
4. Extreme width	74
5. Width at highest point of spine	74
6. Width of supra-spinous fossa here	25
7. Width of infra-spinous fossa here	45

*Measurements of Scapula of Equus.**	MM.
1. Extreme length	414
2. Width of neck	73
3. Width of distal end	107
4. Extreme width	186
5. Width at highest point of spine	146
6. Width of supra-spinous fossa here	48
7. Width of infra-spinous fossa here	93

These measurements show the scapula of *M. bairdi* to have been proportionately more expanded superiorly than that of the horse and at the same time the neck is proportionately more contracted than in the latter.

* No. 338, Princeton Coll.

THE PELVIS (No. 11376).

The pelvis is equine in all its characters and very much like that of the modern horse with some characteristic points of difference. The specimen described below is the first pelvis of *Mesohippus bairdi* that has ever been found showing all the characters, being almost perfect. See Fig. 4, and Plate xiii. It was discovered by Mr. J. W. Gidley during the past summer in the lower Oreodon beds.

Fig. 4.

PELVIS OF M. BAIRDI, ¼.

The most striking difference between the pelvis of *M. bairdi* and that of the horse is that the former is narrower in proportion to its length than that of Equus.

The great breadth of the pelvis anteriorly in the latter is owing to the very great lateral expansion of the ilia, while in the earlier genus they are proportionately less widely expanded. The ilia directly in front of the acetabulum are slender in their proportions and expand more gradually than in the horse, so that they are longer in proportion to their width than in the latter. The bone is widely expanded superiorly and the angle above the point of articulation of the ilium with the sacrum curves upward and outward, and the free end is thickened and somewhat rugose. This upward and outward expansion of angle makes the external border of superior aspect of the ilium concave. The crest is more slender and elongate comparatively than in Equus and is strongly everted. The border of the ilium between the angle and the crest is very thin and strongly concave. The whole anterior expanded portion is thin except along the outer or lower border. The posterior border of the angle above the point of articulation of the sacrum is also slightly thickened. The sacral border of the ilium is large and extends high above the articular facet for the sacral vertebræ forming the angle. The ilia as well as the long axis of pelvis are directed downward at an angle from the vertebral column. The acetabulum is an elongate oval in shape and its borders are elevated and well-defined. The border is incomplete below owing to the encroachment of the pit for the ligamentum teres on the acetabular fossa. This is less emphasized, however, than in the horse. The pit for the ligamentum teres is quite deep.

The ischium is straight and on a line with the long axis of the ilium. The bone curves outwardly posteriorly, but does not curve upward as in the horse. The posterior border is expanded and thickened outwardly where it ends in a stout process, the tuberosity of the ischium. The internal border posteriorly is deflected towards the median line and meets

its fellow of the opposite side at this point forming part of the symphysis. Above the acetabulum the border of bone is high and rounded, but is not sharp and angular as in the horse. The obturator foramen in the pelvis of the latter is rounded and shorter in proportion to its width than in *M. bairdi*, being only slightly elongate, while in the species under consideration the foramen is narrow and very much elongated, the length equaling twice the breadth. This conditions the shape of the posterior portion of ischium, which in *M. bairdi* does not extend far back of the posterior border of obturator foramen, while in Equus the ischium forms a large expanded plate posterior to the obturator foramen.

The pubis is elongate, flattened from above downward and irregularly triangular in shape. The portion of pubis nearest the acetabulum is almost round in cross-section, while in the horse the corresponding portion, as in fact the entire pubis, is very much more flattened. It meets its fellow of the opposite side in the median line forming the anterior part of the symphysis with the bases of the triangles applied together The symphysis is formed by both pubes and ischia conjointly, the former constituting the anterior and larger part while the ischia form the posterior part. Fusion of the pubes is so complete that no trace of a suture remains, while the ischia are not anchylosed together. The anterior part of the symphysis is flattened in the form of a large plate, which bears inferiorly in the median line a prominent spine. All the processes for muscular attachments are less strong and rugose than in the horse. The pelvic foramen (or cavity) is longer in proportion to the breadth in *M. bairdi* than in the horse, being a little longer than broad, while in the latter the pelvic outlet is broader than long. In Mesohippus the length (or vertical height) is about 65 mm. and the breadth 60 mm., while in the horse the reverse condition obtains and we find a length of only 174 mm. as compared with a width of 199 mm.*

Other measurements of the pelvis are as follows:

	MM.
1. Extreme length	209
2. Length of acetabular cavity	26
3. Length of symphysis	63
4. Extreme width of ischia	74
5. Width at acetabulum	102
6. From top of angle to outer point of crest	89
7. From anterior border of acetabulum to point midway between angle and crest	74

Restoration of M. bairdi (Pl. xiii).

In 1879, Prof. Marsh,† in giving the genealogy of the horse, brought out the fact that the chief modifications through which the horse passes in its evolution are the following:

1. Progressive increase in the length of teeth and in their complexity,

* ($6\frac{7}{8}$ x $7\frac{7}{8}$ inches) Chauveau *loc. cit.*

† *Am. Jour. Sci.*, Vol. xvii, p. 497.

from a very short-crowned tooth with distinct roots, to one with very long crown in which roots are not formed till animal becomes adult.

2. The gradual lengthening of the limb bones with the suppression of the lateral digits and the concentration of the growth force in metapodial iii, producing ultimately a monodactyl foot from a pentadactyl ancestor.

3. The continued reduction of ulna and fibula and their ultimate coalescence with the radius and tibia.

4. Gradual increase in size from an animal not larger than a fox up to the modern horse.

Mesohippus bairdi is an interesting intermediate stage in the evolution of the horse; though primitive in many respects, it had already made considerable advance over its Uinta predecessor.

The restoration here given is made from a nearly perfect skeleton which enables us to make some improvements on the one already given,* which, however, was as good as could be made with the material then available.

The lumbar vertebræ, sacrum, pelvis and a few of the posterior dorsals are from another individual reduced to proportion. Part of the skull is also restored from another specimen.

Mesohippus occupies a position about midway in the line of descent of the horse series. It presents the following advances over its Bridger predecessor, Pachynolophus.

1. The teeth are longer (vertically) and more complex, the intermediate cusps are better developed, and the transverse ridges are likewise better developed and more nearly confluent with outer wall of tooth.

2. The lateral metapodials are more reduced comparatively, and metapodial iii is much larger. In the Bridger form the phalanges of the fifth digit are present, but *M. bairdi* has lost these.

3. Both the ulna and fibula are more reduced than in the earlier form

4. In *M. bairdi*, Pms. 2–4 are molariform, while in Pachynolophus Pm. 4 only is molariform and is smaller than true molars. Epihippus, the Uinta representative of the series, has Pms. 3 and 4 molariform, and this is the only generic distinction between the Bridger and Uinta genera.

The orbit is commencing to retreat, though it is still over the molars, the anterior border being directly over the posterior half of M. 1. In the horse it is situated posterior to molar series, and we can trace a gradual transition in the position of orbit up through the different genera from Mesohippus to Equus. This shifting backward of the orbit brings about a gradual elongation of the facial region of the skull. The alveolar border of the maxillaries is low, this of course being associated with low-crowned, short-rooted teeth.

From the character of the teeth we may judge of the life habits of the animal. The teeth of the modern horse have very long crowns

* *Journ. of Morph.*, Vol. v, No. 3, p. 337.

(hypsodont), grow from persistent pulps and do not form distinct roots until the animal is quite old, not until a length of crown is attained which under normal conditions will afford sufficient grinding surface for an average lifetime. As the teeth wear off by attrition the loss is replaced by growth, and growth and wear proceed pari-passu until the animal becomes adult.

The little Mesohippus, with its short-crowned (brachyodont) teeth, inserted by distinct roots, must therefore have fed on succulent plants that grew in swampy, marshy land—as if subjected to wear necessitated by the mastication of the hard, silicious grasses of Miocene times, the teeth would soon have worn out entirely and the animal would have succumbed to starvation. In most of the specimens found the teeth are only moderately abraided.

The feet, too, being tridactyl are adapted to progression along the oozy shore of rivers or to swampy, marshy ground as the toes would spread and thus support the animal in the mud, while the monodactyl foot of the horse is preëminently adapted for rapid locomotion over the grassy plains. This would seem to prove that the life habits of the animal have changed very greatly during its evolution. Many of the White River animals were adapted by their anatomical structure to life in swamps. Some were at least semi-aquatic in their habits, as is denoted by the position of the posterior nares, which in some forms are removed very far backward, *e. g.*, Ancodus.

The skull is equine in its characters, but is still quite small and the facial region is short. The orbit is not enclosed behind.

The neck is long, and, as in the horse, these vertebræ are larger than those of the dorsal region of the column. The processes are not so massive as in Equus, but are quite as complex and are very well developed. The spines of the dorsal vertebræ are not so high as we should expect, and very evidently *M. bairdi* did not have any great elevation of the anterior dorsal region. The modern horse is much higher at the withers than at the haunches. The spines of the lumbar vertebræ are very high and incline forward at quite an angle. There is a very abrupt transition in height of spines from the first sacral, which has a very high spine to third sacral, which has a very much lower spine, though it is still much compressed laterally. Six vertebræ take part in the formation of the sacrum. The centra of the first few caudals are flat with wide transverse processes, but these, as well as all the other processes, gradually become suppressed and the neural arches disappear so that the lower caudals are merely cylinders of bone. It is impossible to determine the exact number of vertebræ taking part in the formation of the tail, but it is fair to imagine that it had one at least as long pro portionately as the horse.

The scapula is remarkable for the persistence of the acromion process, in which character it is unique among all Perissodactyls, with the exception of Pachynolophus (Orohippus) of the Bridger. The spine is better

developed, the bone is lower and broader, the neck is more constricted proportionately than in the horse. In the latter the anterior border of the scapula is not rounded as in Mesohippus. The ulna is very much reduced in *M. bairdi*, and the radius is enlarged to sustain the weight of body. The ulna is distinct from the radius through the whole of its extent, the two bones not being coössified even in old individuals. Below the proximal half the bone is much compressed and tapers rapidly toward the distal end. This gives it a frail character so that it is almost always broken away in fossilization, and only recently have specimens been found which permit an accurate determination of its character. The distal end is not compressed as it is higher up, but is round in cross-section and bears a facet for the cuneiform. A rudiment of the fifth metacarpal persists. All the metacarpals and their phalanges are somewhat shorter and less massive than the metatarsals and the phalanges of the hind foot. The pelvis is thoroughly equine and yet differs in many minor characters from that of the horse. It is narrower in proportion to its length than that of the latter. The ilia expand less abruptly, the crest is narrower and more elongate proportionately, and the ischia do not bend upward posteriorly as in the horse, but are in a straight line with the long axis of the ilia. The obturator foramen is more elongate and narrower transversely, and the pelvic outlet is higher and narrower proportionately than in the modern equine.

The fibula was complete in *M. bairdi;* was very much reduced in size and was coössified with the tibia. The proximal end is quite small, the shaft is filiform, while the distal end alone is quite large and forms the external malleolus articulating with the astragalus, and in extreme extension of the foot also with the calcaneum. The fibula remains complete until John Day times, for in *Mesohippus* (*Anchitherium*) *præstans* Cope from this formation it is retained in its entirety.

The hind limbs are much longer than the fore limbs, more so proportionately than in the horse, so that the rump must have been much elevated above the withers if the different elements of the limb were not very much more flexed on each other than would seem justifiable, judging from recent animals. Many of the White River animals had a curved arched back instead of a straight back as in the horse, *e. g.*, Hyænodon, Leptomeryx, etc. This is shown by the character of the centra of the vertebræ. The great individual variations met with in *M. bairdi* have been noticed by every investigator who has studied a series of specimens of this species. These variations are principally in the limbs and teeth. Some of these have already been noted. In several individuals the three cuneiforms of tarsus are all coössified into a single compound cuneiform. Usually the ento- and meso-cuneiforms are united.

There is usually a moderately large contact of metatarsal iii with the cuboid, this latter usually extending below the level of the ecto-cuneiform, so that all contact of metatarsal iii with cuboid is lateral. In some specimens there is a slight extension outwardly of the proximal

end of M. iii and the cuboid is slightly shorter, so that it articulates with the distal end of cuboid instead of being confined to mere lateral contact. The antero-internal angle of cuboid is accordingly somewhat modified in shape to correspond with the changed outline of metapodial iii. This is a tendency in the direction of *M. intermedius* of the Protoceras beds, and a foreshadowing of the condition in the modern horse which has such a large facet on the cuboid for the widely expanded proximal end of metatarsal iii. Between this condition and that where there is only lateral contact with the cuboid, we find all the intermediate stages. Again, there is a great deal of variation in the relative proportions of the lateral digits to each other, and in the relation they bear to the median digit. Sometimes the lateral digits are not much reduced and are subequal in size, while again we find the lateral digits very much reduced, and Mt. iv, at least proximally, is usually larger than Mt. ii.

In *M. bairdi* usually there is no confluence of posterior transverse crest with the outer wall of tooth, usually separated from it by a large interval, but occasionally we get an individual in which there is actual confluence, and we get all stages intermediate between these two extremes. We get individuals where the interval between outer end of transverse crest and outer wall is less, and, again, others in which there is a small process jutting inward from the point of union of outer lobes, toward the transverse crest, these separated by a very small interval, and then we get complete confluence. These highly specialized forms were, of course, not ancestral, but were prematurely modernized and left no descendants. However, these individuals most specialized occur highest up in the beds, showing that these variations are attempts in the way of evolution.

Mesohippus Copei.

This is a new species of horse from the White River, which has just been described by Osborn and Wortman.* In their description of the type no specific characters other than those of size are given, by which it may be distinguished from the two other species from this horizon. This species was founded upon a complete half of a pelvis, femur, tibia and part of a hind foot, together with a median metatarsal and one lateral metatarsal of another individual, a collateral type. "These remains indicate an animal of much larger size than those of *M. intermedius*, and, so far as we know, is the largest horse of the White River epoch, even larger than *Mesohippus* (*Anchitherium*) *præstans* of the John Day." The species is undoubtedly well founded, but the material in the Am. Museum did not permit the establishment of good specific characters. I have studied carefully the material upon which the species is founded and have been able to refer some material in the Princeton Collection to this species. This material consists of the distal end of a

* *Bull Am. Mus.*, Vol. vii, pp. 35?–358.

femur, tibia and almost complete hind foot, and enables me to give some further characters of the species. *M. copei* differs from *M. bairdi* in the following respects: (1) The lateral metapodials curve outwardly quite sharply distally and the toes were thus more spreading than in *M. bairdi* (see Fig. 5). (2) The meso-cuneiform is proportionately less deep than the ecto-cuneiform than in *M. bairdi.* (3) The carina or median keel of the distal end of metatarsal iii, which in the smaller species is almost entirely confined to the plantar surface of the bone, in *M. copei* extends far up in the dorsal surface of the distal end of the bone. (4) The lateral metapodials are comparatively shorter than the median metapodial, so much so that the ungual phalanges could scarcely have been functional at all, and this form had progressed farther toward monodactylism than any other known form from the White River. (5) The combined depth of the navicular and ecto-cuneiform was greater than in *M. bairdi*, and greatly exceeded that of *M. intermedius.* (6) The cuboid did not extend below the level of the ecto-cuneiform. Metatarsal iii was borne by the latter alone and did not extend over on the cuboid, so that anteriorly there is no contact of these two bones either lateral or distal as in both the other species.

The tibia is about one and one-half times as long as that of *M. bairdi*, and is proportionately much stouter.

The shaft is very long, even longer than that of the John Day species, but is more slender, and seen from the side it presents the characteristic sigmoid curve. The cnemial crest is very high, curves slightly outward and has the usual tendinal sulcus on its outer border. It extends farther down on the shaft than in *M. bairdi.* The proximal surface is very much more rugose than in the latter. The femoral facets slope downward and backward at quite an angle. The outer facet is convex antero-posteriorly and concave transversely. The inner facet is concave antero-posteriorly and convex transversely. The distal end of tibia is turned slightly outward. The distal end of tibia and fibula together are proportionately wider than those of *M. bairdi.* The facets for the trochlear surface of astragalus are deeply incised, are oblique in position and are separated by a high intertrochlear ridge.

The proximal end of the fibula is not preserved, but the very large distal end and a portion of the shaft persists. Rugosities on the outer border of tibia indicate that it was complete and closely applied to the latter. The portion of the shaft preserved is very much reduced. The expanded distal end forms the external malleolus and bears the two usual facets.

The tarsus presents striking differences from that of *M. bairdi*, and can best be described by instituting a comparison between it and the latter.

The calcaneum is stouter and more massive, but has about the same relative proportions as in *M. bairdi.* The tuber calcis is large and rugose for the insertion of the tendo Achillis. The tuberosity is quite high

with its inferior border slightly convex. The upper border is broken away. The tuberosity is much thicker and more massive than in the smaller species, where all the bones are gracefully shaped. The sustentaculum is very strongly developed and bears a large facet for the astragalus, which facet is elongately oval in shape. The crest formed by the superior or ectal astragalar facet is broken off so that its character cannot be determined. There is a slight prolongation of this facet antero-externally which is somewhat more emphasized than in the smaller species. The inferior facet is near the distal end, and is the smallest of all the facets of calcaneum, and does not extend far back from the distal end—elongate in shape. The facet for the cuboid is large, occupying all the distal end of the bone which is more obliquely truncated than usual. The shape is triangular with the apex towards the sustentaculum.

Fig. 5.

LEFT FOOT OF M. COPEI, ¼.

The astragalus is merely an enlarged copy of that of *M. bairdi* with some differences of detail. It is proportionately broader. The trochlea is more widely open and the condyles are higher and thicker. The neck is of about the same relative proportions as in *M. bairdi*. The internal condyle as usual is the longer of the two and anteriorly slightly overhangs the navicular facet while in the smaller species it does not quite reach it. The outer condyle is very much shorter than the inner and is separated from the navicular facet by quite an interval.

The navicular is a flat bone, is wide transversely and seems proportionately higher than in *M. bairdi*. The proximal articular surface is strongly concave antero-posteriorly for the corresponding surface of astragalus. Posteriorly there are two elevations on the inner and outer borders respectively, between which is a wide and shallow depression for the projection on the inferior margin of distal surface of the astragalus. The external margin of this latter projects strongly downward, extending around the outer edge of navicular. These two characters make a very close interlocking joint so that there is scarcely any direct lateral movement possible. This interlocking is not quite so complete, however, as in *M. bairdi*, as in this latter the external margin of inferior surface of astragalus extends farther down on outside border of navicular. This outside projecting border is in the form of a crest which is placed obliquely on bone and limits the direction of the movement of the two bones taking part in this articulation on each other to an oblique motion. The distal surface of bone presents a large triangular facet for ecto-cunei-

form. Coalescing with apex of above is a facet extending up on posterior border of bone, which articulates with cuboid. On the proximal surface there is a small facet on the antero-external corner of bone, which articulates with the calcaneum by a small facet just above the inferior astragalar facet and which seems to be a part of the latter, but on close examination proves to be a distinct facet. In *M. bairdi* the navicular just touches the calcaneum, but does not have such distinctly marked facets. This character is seen in some individuals, but in all observed specimens the contact is smaller.

The ecto-cuneiform is high and massive, the breadth being twice the height. The proximal facet for navicular is concave, both antero-posteriorly and transversely. The inferior (or distal) facet is concave in both these directions. On the external side it abuts against the cuboid, and this latter seems to have been just equal in length to the combined length of ecto-cuneiform and navicular. It bears no facet either lateral or proximal for metatarsal iv.

The coössified ento- and meso-cuneiforms show an emphasized condition of that of *M. bairdi*, in that the tendency of the distal row of tarsal bones to form a closed circle is more marked here. The portion representing meso-cuneiform bears most all of the proximal end of metatarsal ii. The ento-cuneiform is high and compressed transversely and curves strongly backward and around towards the other side of foot. On its inferior surface it bears a facet at its point of contact with metatarsal ii.

The metatarsus of *M. bairdi* exhibits the following characters: (1) The cuboid which bears metatarsal iv extends down below the external cuneiform which bears M. iii. (2) The meso-cuneiform does not quite reach to level of the ecto-cuneiform. From this it results that M. iv does not quite reach up to level of M. iii, while M. ii reaches above the latter. In *M. copei*, M. iv extends quite up to the level of M. iii, while the meso-cuneiform is not so deep proportionately as in the smaller species. Metatarsal iv is proximally much less reduced than M. ii, but tapers to about the same size distally. It is borne entirely by cuboid. The disproportion in size of the proximal ends of the two lateral metapodials can hardly be more than an individual character, as we find all degrees of difference in the relative sizes of the two lateral digits in the smaller species.

In some specimens the two lateral digits are of the same size, in others subequal with the ivth slightly the larger and in others this digit is very much larger than ii. One individual exhibits the very peculiar character of having the lateral metapodials of the same size on one foot, while in the opposite foot the fourth metatarsal is much larger than the second.

Metatarsal ii is slightly less reduced than in the average individual of *M. bairdi*. Proximally it bears a large concave facet for the meso-cuneiform and posteriorly there is a small facet by which it abuts against the inferior retroverted edge of the ento-cuneiform. This latter extends

both above and below the meso-cuneiform and conditions the shape of the head of M. ii, about one-half of the proximal surface being supported by the meso-cuneiform. Posterior to this facet the proximal surface slopes abruptly downward and presents the above-mentioned facet. About two-fifths of the internal surface of ecto-cuneiform is taken up with a facet for metatarsal ii, which in *M. bairdi* extends upward proportionately less on the ecto-cuneiform. The shaft is of about the same dimensions proportionately as in *M. bairdi* and was closely applied to M. iii proximally, but both the lateral metapodials curve outward distally. The distal end is merely an enlarged copy of that of the smaller species, is high and compressed and the median keel is strongly developed. Metatarsal iii bears about the same relation to the lateral metatarsals in size as in *M. bairdi.* In the latter we have a distinct facet on M. iii, either lateral or proximal for the cuboid, but in the new species M. iii does not touch the cuboid and the only facet on exterior surface of the proximal end is that for M. iv. It is borne entirely by the ecto-cuneiform and is quite large in proportion to the size of the lateral digits and supports nearly all the weight and receives most of the impacts and strains of the foot. The distal end is somewhat wider than the proximal end. M. iii is quite a little longer than the lateral metatarsals, more so than in *M. bairdi.* All the phalanges are slightly more massive proportionately than in the smaller species.

The pelvis in the Am. Mus. Collection referred to *M. copei,* I do not regard as Mesohippus at all because it is too much specialized in its own way to belong to a White River equine. It differs very much from that of *M. bairdi* and in some respects is more specialized than that of the modern horse. If the reference to *M. copei* is correct, we have in this species a very aberrant side line of the horse series. The pelvis under discussion differs from that of *M. bairdi* in the following respects: (1) The ilium expands very abruptly, almost directly in front of the acetabulum, while in *M. bairdi* it expands very gradually and begins its expansion a long way in front of the acetabulum (see Pl. XIII and Fig. 4). (2) The angle of the ilium in *M. bairdi* and of all the known equines is sharp, but in this specimen it is very much rounded. (3) The crest is broad and stout instead of being narrow and elongate as in *M. bairdi.* (4) The border between angle and crest is very much less concave than in *M. bairdi* and the horse. (5) The border of bone above acetabulum is drawn out into a sharp crest even more pronounced than in the recent horse. (6) The acetabulum is round as in Hyracodon, not elongate as in *M. bairdi* and the horse. (7) The obturator foramen is broader in proportion to its length than in *M. bairdi.* (8) The ischia turn upward at an angle posteriorly almost as much as in the horse, while in *M. bairdi* the ischium is in a straight line with the long axis of the ilium and does not turn up posteriorly. In view of these great differences I cannot regard the reference to *M. copei* as correct.

In the American Museum there are a series of lumbar vertebræ which

are too large for *M. intermedius*, and their provisional reference to *M. copei* is justifiable. These are very like those of *M. bairdi*, but much larger and more massive. The provisional reference of the two premolars described with the type is also justifiable, as they are too large to pertain to any other known species of horse from the White River. Leaving the pelvis out as questionable, we may say that the remains indicate a very large equine agreeing with *M. bairdi* in most of its characters and yet specialized in its own way so that it is a little off the line of equine descent though most probably developed from *M. bairdi*.

Measurements of M. copei.

	MM.	MM.
Tibia	298	313
Calcaneum, length	82	
Calcaneum, extreme width	30	
Astragalus, length	46	50
Astragalus, width of neck	31	37
Height of navicular	11	
Height of ecto-cuneiform	11	
Length of M. iii	177	189
Femur, distal end width	51	
Width of patellar surface	29	
Extreme length of first phalanx of M. iii	24	
" " second " "	11	
" " ungual " "	29	
Length of M. iv	155	
Phalanx 1 of M. iv	14	
" 2 "	9	
" 3 "	22	

MESOHIPPUS INTERMEDIUS O. and W.

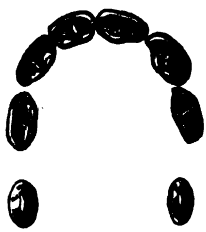
M. intermedius, as the name indicates, stands intermediate between *M. bairdi* of the Oreodon beds and *Mesohippus* (*Anchitherium*) *præstans* of the John Day. It occurs in the Protoceras beds. It is a strange and interesting fact that *M. bairdi* continued on into the time of the Protoceras beds after having given rise to the two species.* A careful study of the principal characters of *M. intermedius* brings out very strongly its relation to the preceding and succeeding species. In all these points it is seen to stand directly intermediate between *M. bairdi* and *Mesohippus* (*Anchitherium*) *præstans* of the John Day. In the light of present knowledge there can be no doubt that *M. bairdi* is the direct ancestor of the modern horse, and by the study of the individual variations of the

* A remarkable instance of the persistence of an ancestral type is seen in the Loup Fork. Here Protohippus, a form with long-crowned, cement-covered molars, represents the main line of equine descent, while right alongside of it there is a much smaller species of *M. bairdi* type which Cope has called *Anchitherium ultimum*. This form has short-crowned molars, without cement.

former we can trace a tendency toward the establishment of the *M. intermedius* type.

The skull of *M. intermedius* is much more equine in character than that of *M. bairdi*. It presents the following differences which may be looked upon as modernizations: (1) Increase in length, size and in general proportions. The largest skull of *M. bairdi* observed measures 218 mm., while that of *M. intermedius* measures 280 mm. (2) The upper incisors are all pitted (see Fig. 6), while in the smaller species only the two outer pairs have the enamel invagination. (3) The facial region of the skull is more elongate and the orbit is shifted backward. In *M. bairdi* the anterior border of orbit is over M. 1; in *M. intermedius* it is over interval between Ms. 2 and 3. (4) The diastema between Pm. 1 and the canine is proportionately greater in the larger species.

Fig. 6.



SUPERIOR INCISORS AND CANINE OF M. INTERMEDIUS, ½.

The canine has a well-developed cingulum on its internal surface. This is the foreshadowing of the cupping, as the pit in an incisor tooth is formed by the cingulum, which rises up on the internal border of the tooth to enclose the depression. Teeth have been observed from the lower Oreodon beds which have a strongly developed cingulum anticipating the development of the pit. (5) The occiput is slightly more overhanging in the larger species. (6) The aveolar border of the jaw is better developed and higher in *M. intermedius*. This, of course, is correlated with larger teeth, with longer roots. (7) The postorbital processes are better developed, more nearly enclosing the orbit. (8) There is in *M. intermedius* a large deep antorbital fossa or depression occupying nearly all of the lateral wall of skull and extending forward almost to Pm. 1. (9) The teeth of the molar series are much larger, longer and more specialized than those of *M. bairdi*. These differences, which have been given by Osborn and Wortman in their description, are: (*a*) "The internal cingulum of Pm. 1 is more strongly developed and a distinct basin is formed. (*b*) In the second upper premolar, the parastyle or antero-external buttress is considerably larger than in *M. bairdi* and gives to the crown an incipient triangular shape. (*c*) The midrib of the external lobes is better developed than in *M. bairdi*, and the postero-transverse crest is more nearly confluenced with outer wall of tooth."

Length of Molar-Premolar Series.		
M. bairdi.... 73.5	*M. intermedius*.... 97	*M. præstans*.... 112.5
	Molar Series.	
23	46	51
	Premolar Series.	
42	53	61

The Milk Dentition.

In the Princeton Collection there is a skull bearing the temporary dentition (No. 11168). In the young skull the anterior border of the orbit is just between D. 4 and M. 1, so that as growth takes place the orbit is forced to retreat by the elongation of the facial region of the skull, as in the adult skull the anterior border of the orbit is over the interval between molars 2 and 3. The milk teeth agree in all essential points with those of *M. bairdi.*

Measurements of the Superior Milk Teeth.

	MM.
Length milk series	57
D. 1	10
" 2	18
" 3	16.5
" 4	17

The lower teeth of the deciduous set agree in all their characters, except size, with those of *M. bairdi.*

There is nothing noteworthy about the vertebræ except their increase in size over those of *M. bairdi.* The limbs bear the same general proportions as in the smaller species. The scapula is higher and narrower proportionately than in *M. bairdi.* All the limb bones are characterized by being much longer than in the smaller species. The ulna is not more reduced distally than in *M. bairdi,* and is distinct from the radius throughout. The shaft is compressed laterally and is very slender, but distally it is stouter and has a large facet for the cuneiform. Proximally the olecranon is more massive than in *M. bairdi.* The radius is very large and is fast becoming the important bone of forearm. The carpus presents no important differences from that of the smaller species. It is still high and narrow. A rudiment of the fifth metacarpal still persists, but is not so elongate as in *M. bairdi,* but is shorter and stouter and on the way to disappearing. The lateral digits are usually more flattened than in the smaller species but are not more reduced, the distal ends being even more massive proportionately. The ungual phalanges of the lateral digits are long, narrow and sharply pointed at the ends. That of metacarpal iii is proportionately wider than that of *M. bairdi.*

	MM.
Length of M. iii	155
" M. iv	138
" M. ii	143

The ribs are characterized by their length and extreme slenderness, those of the median dorsal region being especially long, not much flattened, being almost round in cross-section. The pelvis presents few characters that are new. The ilia expand even more gradually than in *M. bairdi.* The angle rises up in a pointed process. The crest is partly

broken away so that all its characters cannot be determined. The border of bone above the acetabulum is rounded and not sharp. The ischia turn upward slightly posteriorly and form more of a plate posterior to the obturator foramen posteriorly than in the smaller species. The sacrum has five vertebræ entering into its formation. The spines of the lumbars are still very high, but they have a more considerable antero-posterior extent proportionately than in *M. bairdi.* The femur has a massive proximal end, the great trochanter being lower and more massive than we usually see it in Mesohippus, but this may in part be due to the fact that our skeleton is of a young animal.* The tibia of *M. intermedius* is somewhat stouter in proportion to its length than that of *M. bairdi.* The cnemial crest is strong and well developed. As usual, there is a large fossa external to the cnemial crest. The fibula is still complete and is distinct from tibia. The proximal end is quite small and the shaft is very much reduced, while the distal end is quite large, forming the external malleolus to articulate with astragalus and with calcaneum in extreme extension. Both proximal and distal ends, as well as the shaft, are closely applied to the tibia, but are not coössified with it. The tarsus of *M. intermedius* is more modern than that of *M. bairdi* in that the tarsus is wider and lower, which is a step in the direction of the modern horse. The calcaneum is very long, the tuber proportionately longer than in *M. bairdi,* and is quite stout with an expanded free end. The cuboidal facet is long and narrow, almost crescentic in shape and extends downward and inward to the sustentaculum. There is quite a large fibular facet. The astragalus is broader and the trochlea is not so deeply incised as in *M. bairdi,* though it is distinctly equine in pattern. The two condyles of the astragalus are very unequal in size. The inner almost always overlaps the navicular facet, while the external is separated from it by a long interval. In *M. bairdi* the internal condyle never reaches the navicular surface. The navicular is much flatter and lower, as is also the ecto-cuneiform, than in *M. bairdi.* The cuboid is also shortened, just equaling the height of the two contiguous bones. metatarsal iii extends over on cuboid.

This is another modernization. There is a distinct facet on the calcaneum for the navicular. There is a much more complete interlocking of the tarsal bones in *M. intermedius* than in any other White River horse. The ento-cuneiform as usual is high, extending both above and below the meso-cuneiform which is still not so deep as the ecto-cuneiform. On its posterior surface it bears a distinct facet for the cuboid with which it unites in forming the small facet for M. iv. Metatarsal iv is usually less reduced proximally than M. ii, but tapers to about the same size distally. This demonstrates the manner in which the reduction of digits takes place in the family. We know from *M. bairdi* that M. i first disappeared and afterward M. v. The condition in *M. intermedius* indicates that M. ii would next become rudimentary, and then M. iv. In the horse where the lateral metapodials are mere splint

* This may also account for the fact that fibula is not coössified with tibia.

bones and closely applied to M. iii, M. iv is still larger than M. ii proximally.

The inter-relationships of these three species may be expressed by the following diagram:

Protoceras Beds.	M. bairdi.	↑ M. intermedius.	M. copei.
Oreodon Beds.	↑ M. bairdi.		M. copei.
Titanotherium Beds.	↑ M. bairdi.		

The phylogeny of the horse series as it is now generally understood may be given as follows:

Pliocene to Recent	Equus	Hippidium
Loup Fork	Protohippus	Hipparion
Deep River	Desmatippus	Anchitherium
John Day	Mesohippus	
White River	Mesohippus	
Uinta	Epihippus	
Bridger	Pachynolophus	
Wasatch	Hyracotherium	Palæotherium
Puerco	Condylarthra	Protogonia Protogonodon

↑ Represents the line of descent.

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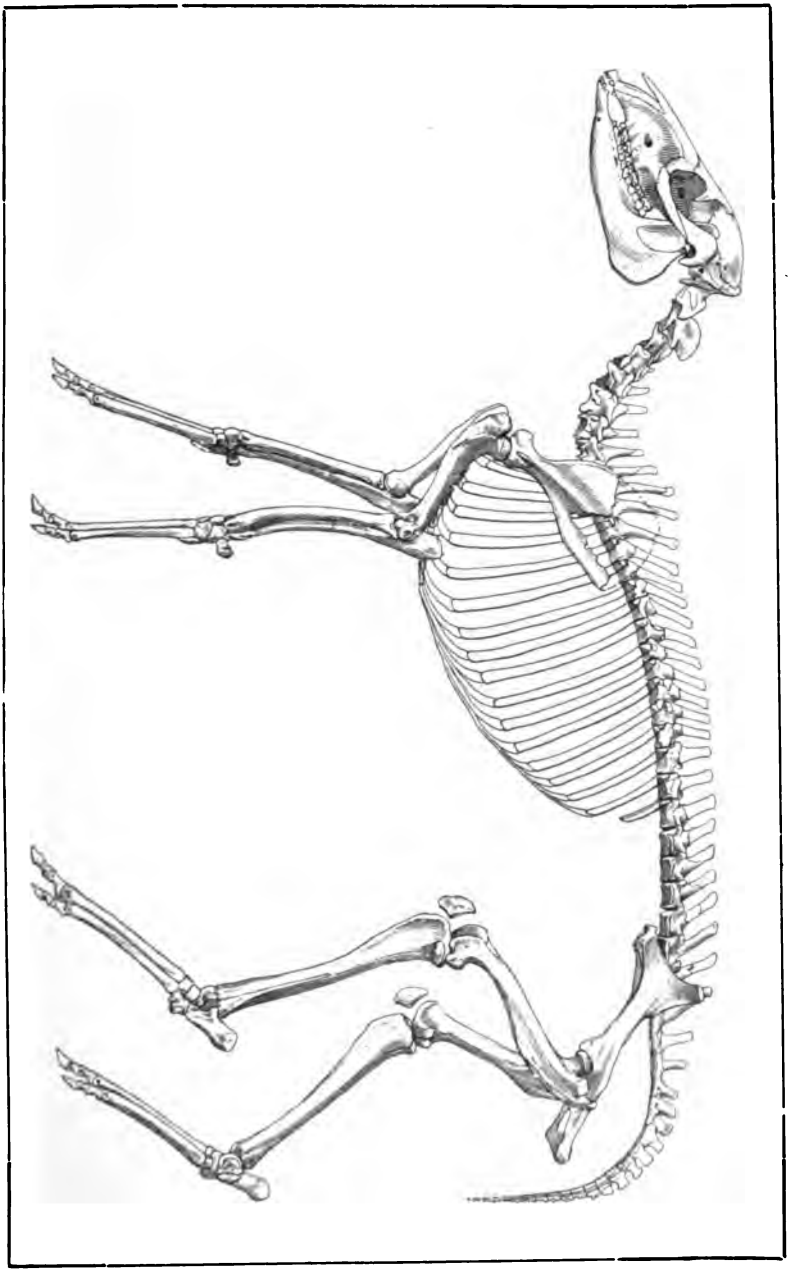

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On Natural Selection and Separation.

By Arnold E. Ortmann.

(Read before the American Philosophical Society, May 15, 1896.)

I. It is generally understood that the chief merit of Darwin in creating his theory of the origin of species is the establishment of the principle of Natural Selection, and that by the introduction of this principle the process of development of organic nature from the conditions existing in former times to the present may be made intelligible, and mostly it is also understood, that natural selection is only one of the factors playing a part in the formation of species. But the proper line of action of natural selection, as conceived by Darwin, is estimated by some other authors very differently. I refer especially to Weismann, who calls natural selection "all-sufficient," which implies that it is the only factor that forms species; but I regard this expression only an exaggeration, since Weismann contradicts himself in this respect.* The assertion, however, stands, that natural selection of itself *may* form different species. On the other hand, Eimer maintains, in opposition to Weismann, that there is

* See Ortmann, *Grundzüge der marinen Tiergeographie*, 1896, p. 30.

no formation of species by natural selection, but that the only action of this factor consists in the preserving of existing species.* This opinion is as erroneous as that of Weismann, but in the opposite direction.

So far, however, Darwin's definition of natural selection, as the survival of the fittest, was not altered, only the efficacy was regarded differently. But recently Pfeffer† has given another conception of natural selection, differing from Darwin's. According to the latter, by the struggle for existence the fittest are selected (hence the term "selection"), while all others are destroyed. Pfeffer, however, says that there is no selection of particularly good variations, but the struggle for existence destroys indiscriminately fitted and not fitted individuals, and certainly it destroys all the not fitted. Thus the surviving remainder (according to Darwin's terminology the selected part) consists of a number of good and better individuals, which show a *good average*. The struggle for existence continued in this way during many generations—destroying all the bad individuals—effects little by little that this good average improves from generation to generation. Pfeffer calls this process "Transformation of species by self-regulation" ("Umwandlung der Arten durch Selbststeuerung").

This conception of natural selection differs only slightly from that of Darwin, and one could say, that only the form of expression is different, while the effect in both cases is the same. But we shall see below, that the form used by Darwin is in some respect inferior to that used by Pfeffer, and although Darwin's meaning is nearly the same as that of Pfeffer, we shall have some advantage in accepting Pfeffer's phrase, especially in maintaining, that not the fittest, but good individuals survive, and that the change effected is an extremely slow one.

Recently I have pointed out,‡ that this "transformation of species" is nothing else than the well-known "mutation" of palæontologists, a term, the differences of which from "variation" are first shown by Waagen and Neumayr, and subsequently most vigorously maintained by W. B. Scott.§ These differences are neglected by many zoölogists, although the "comparatively lawless and uncontrolled character"‖ of the variations and the "directness of advance towards the final goal"¶ of the mutations differ strikingly. Scott says:** "While variations are due to the union of changing hereditary tendencies, mutations are the effect of dynamical agencies acting long in a uniform way and the results

* Eimer (*Die Artbildung und Verwandtschaft bei Schmetterlingen*, ii, 1895, p. 33) uses even the expression: "Inefficiency of Natural Selection" ("Ohnmacht der Naturzüchtung")

† Pfeffer, "Die Umwandlung der Arten, ein Vorgang functioneller Selbstgestaltung,' *Verhandl. Naturw. Ver. Hamburg* (3) i, 1894.

‡ *Grundzüge der marinen Tiergeographie*, p. 31.

§ Scott, "On Variations and Mutations," *Amer. Jour. Sci.*, 48, 1894, pp. 355–374.

‖ *l. c.*, p. 370.

¶ *l. c.*, p. 360.

** This sentence is first given in the paper "On the Osteology of Mesohippus and Leptomeryx," *Journ. Morphol.*, v, 1891, p. 388, and repeated *l. c.*, p. 372.

controlled by natural selection." If thus mutation is influenced by natural selection, it implies, that any particular mutation must advance in a direction advantageous for the respective species, and, indeed, many examples of mutation known among fossil animals are apparently due to the advantage produced by the change.* I must add here, however that probably not all mutations (in a palæontological meaning) are due to natural selection, but that many do not imply an actual improvement. In this respect Eimer's investigations of the Papilionidæ are important. The variations in the colors of the wings, on which Eimer exclusively relies, are apparently neither useful nor injurious, yet they are caused most likely by external conditions, for example, by warmth or cold during the development of the imago from the larva. Eimer points out, that in his butterflies a distinct direction of variation is evident, which he calls "Orthogenesis." We shall see below that this is a process of inheritance. By the constant action of certain external causes upon subsequent generations, and the repeated inheritance of the characters thus acquired, a certain tendency of variation in a distinct direction may develop. If this tendency does not bear on utility, the degree of variation in the single individuals differs considerably, and even individuals varying in other directions are preserved. Thus a gradual transition results from the less to the more changed individuals. But altogether, from generation to generation, the variation in that direction increases, and the changed individuals may become the most numerous, thus effecting a slow change of the average characters of the species, which looks exactly like a mutation. We may call this latter mutation, produced by accumulative inheritance, by Eimer's term "orthogenesis," in contrast to the "mutation" produced by natural selection. "Orthogenetic mutations" are also known among fossil animals, and I refer† especially to the group of Ammonites whose mutations have been first studied. Here most of the characters advancing in certain lines, ornaments and form of the shell, etc., are apparently not subject to natural selection. Of course, we do not know, in most of the cases, whether a particular transformation is useful or not, and in many cases, where we cannot recognize any advantage, the latter is present nevertheless. But since Eimer's investigations have amply proved that such changes, indifferent as regards utility, are certainly present in living animals, they must also have been present in fossil animals ‡

* I mention only the example of the transformation of the structure of the extremities in the horse-phylum, as discussed by Scott (*l. c.*, p. 368). With the change of one character in a useful direction the change of others may be connected, which are in correlation with the first. This would be an indirect action of natural selection."

† A very illustrative example of "Orthogenesis" is the transformation of the Miocene and Pliocene *Fulgur contrarius* into the Pliocene and Recent *Fulgur perversus*. See Leidy, "Remarks on the Nature of Organic Species," *Trans. Wagner Free Inst. Sci.*, ii, 1889, p. 51ff., Pls. 9 and 10.

‡ Weismann indeed denies, even in respect to Eimer's butterflies, that there are any useless variations, but this is one of his many assertions, which he does not even try to establish properly (comp. "Germinal Selection," *The Monist*, Vol. 6, No. 2, Jan., 1896,

We cannot say, however, that animals subject to orthogenesis are not at all under the influence of natural selection: the latter must necessarily act also upon them, since all injurious variations are destroyed and cannot be transmitted and give cause to orthogenetic mutations. Natural selection does not invariably imply mutation, but often, especially if the external conditions are unchanged, it effects only a *preservation* of an existing species: by destroying all bad individuals it maintains the good standard of the characters of the survivors, and only if there is any advantage in any variation, this standard will be improved in a direction indicated by this advantage. Thus we may say that natural selection gives origin to mutation in a useful direction, but that this mutation is very slow, and often so infinitesimal, that it amounts almost to nothing, that is to say, only the good standard is saved. This action of natural selection effects besides the general adaptation of each animal form: the surviving individuals comply with the requirements of the surrounding conditions of life.

We have no reason to look upon natural selection as a factor of minor importance, as Eimer is inclined to do. Even the preserving of a good standard is all-important. Natural selection is a factor which cannot be left aside, and which is a necessary one in the development of all beings, and it is a grave mistake to abate its value in favor of any other factor coöperating in the formation of species.

II. Yet the value of natural selection has not only been underrated by some authors, but, on the contrary, it has been overrated, especially by Weissman. The latter believes that natural selection does form species. One can hardly understand on what grounds he is induced to allege this action, and why he even believes that it is the only factor in the formation of species, since he himself accepts Darwin's conception of this factor, namely, that it acts selectively upon the best variations, and destructively upon all the others, thus inducing only a change, a transformation of *one* existing form or species into *one* other, but never causing the origin of *divergent* forms or species. This point is so plain, and so beyond any doubt, that only a great logical mistake, and a complete misapprehension of Darwin's theory on the part of Weismann can explain this error. Yet it is perhaps a little difficult, to say precisely, where the fallacy is hidden, and it would be interesting to examine this point more closely.

I have no doubt that this wrong interpretation of natural selection is

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p. 251). Weismann's argument as respects this point is the following: Eimer believes to have shown, that there are no advantages for the respective species visible in the different colors of the butterflies: but since I (Weismann) have propounded the theory, that all characters are due to natural selection, the latter must have produced these color markings also, and we must *assume*, that they are or were nevertheless advantageous! Comp. Spencer (*The Inadequacy of Natural Selection*, 1893, p. 49): "He (Weismann) practically says: Propound your hypothesis; compare it with the facts; and if the facts do not agree with it, then assume potential fulfillment, where you see no actual fulfillment."

due to the form in which Darwin has given the definition of this term. I am confirmed in this belief, as the same error is committed again and again. Still very recently, at the last meeting of the German Zoölogical Society, in the discussion following Eimer's discourse, Ziegler* expressed his opinion that no important difference exists between Darwin's natural selection and Pfeffer's; that it is irrelevant whether one says that the fittest is selected, or that the not fitted are destroyed: both processes have the same or nearly the same result, as may be at once understood by an example he quotes from the breeding of races in domesticated animals.

But even this reference to man's selection in domesticated animals, and the unconditional comparison of it with natural selection, is the weak point, and apparently the term "selection" used by Darwin† induced this error. I shall demonstrate here, that both processes, the natural and the artificial, are certainly not identical, although apparently similar, and especially that the final results of both are entirely different. It is true, Darwin himself avoided this mistake,‡ but it was certainly made by subsequent authors, and especially Weismann must have fallen into it, since his odd misinterpretation of natural selection could otherwise hardly be intelligible.

Weismann apparently has reasoned in the following manner. Natural selection effects that individuals possessing certain useful characters are preserved in the struggle for existence, and man's selection in domesticated animals has a similar effect, preserving individuals provided with certain characters desired by the breeder. Consequently both processes are completely identical, with the only modification, that in the first the principle of utility is ruling, in the second the wishes of man. Farther, since in domesticated animals a great number of varieties or races are often obtained from a single original species, and since these races do not differ in their morphological differentiation from natural species, and indeed are perfectly analogous to the latter as regards their relation to the ancestral forms, it was believed that the natural species originated exactly in the same manner, that is to say, since under domestication different races are obtained by man's selection, in nature different species are formed by natural selection. By this argument, I believe, Weismann came to the view, that species are formed by natural selection alone, and although this opinion of the complete parallelism of natural and man's selection is nowhere explicitly given in his writings, we have to infer it.§

* See *Verhandl. deutsch. Zoolog. Gesellsch.*, 1895, p. 129.

† Darwin, *Origin of Species*, 6th ed., 1878, p. 49: "I have called this principle, by which each slight variation, if useful, is preserved, by the term Natural Selection, in order to mark its relation to man's power of selection." Comp. also p. 65, *ibid.*

‡ It is well to be noted that Darwin did not commit this mistake, and that he always regarded natural selection only as taking part in the formation of species, but not as the only cause of it. This is already amply demonstrated by Romanes ("The Darwinism of Darwin and the Post-Darwinian Schools," *The Monist*, Vol. 6, No. 1, October, 1895, p. 3ff.).

§ I do not know whether I have succeeded in trying to follow Weismann's thoughts, but I confess freely: if he did not reason as I have conjectured above, I am at a loss to understand him at all on this point. But if the latter is the case, I do not think it is a fault of mine.

But if we analyze the action of man in breeding, we shall find that it does not correspond to natural selection, but is more complex, and that accordingly the final result obtained by man is different from that in nature.

The breeder selects from a certain species a number of individuals fitted for his particular intentions. The whole number of individuals of this species is thus divided into two parts: the *selected* and the *rejected*. By natural selection also the individuals of a species are divided into two parts: the *fitted* and the *unfitted*. There seems to be complete analogy, but this is not the case. In natural selection, as we have seen above, the fitted survive, and the unfitted are destroyed. But in man's selection there is a difference: of course, the selected corresponding to the fitted survive, but the rejected corrresponding to the unfitted are not invariably destroyed. On the contrary, they survive too, at least a great number of them. It is not at all in the breeder's power to kill all the individuals not wanted of the species under domestication; he may kill of a particular litter, perhaps of all his stock those not corresponding to his wishes, he may continue this killing during a series of generations, but he never can succeed in destroying all the rejected individuals of the original species with which he deals. On the contrary, this original species will propagate, and will continue to exist beside the new race obtained from it. The result of the breeder's art is a new race coëxisting with the original species.

See the difference. Natural selection preserves only a number of individuals possessing a certain number of useful characters, while all the others are destroyed: it preserves the good standard of the species or may even improve it. Man's selection, however, gives origin to a new race branching off from the original species, which is preserved, too, and may be subject for itself to the action of natural selection or may be domesticated and subject to breeding again. Therefore, it is easily understood, that it is certainly incorrect to look upon natural selection and the art of the breeder as analogous processes, and natural selection cannot be the cause of the origin of different species.

We may, however, safely say that the races obtained by the breeder are analogous to natural species, and we are to examine by what additional factors the complete parallelism of the breeding of races and the formation of different species in nature is accomplished.

Recently* I have endeavored to demonstrate that we are to imagine natural selection supplemented by the process of *Separation* (or *Isolation*), in order to understand the development of coëxisting different species from one original species. The main point in separation is the action of different conditions of life in different localities separated from each other. The descendants of one ancestral form, if separated *under different conditions*, tend to develop separately, and the directions of either mutation or orthogenesis become different in each separated group: another

* *Grundzüge der marinen Tiergeographie*, pp. 31, 32.

average fitted for the particular conditions of life, or another direction of orthogenesis prevails among the surviving individuals of each group, and after a *permanent* separation during a series of generations the changes in each separated group amount to what is called specific differences.

If we compare in this respect the origin of species in nature with the art of the breeder, we see at once that separation is implied in the action of man. The breeder not only selects his material—in so far he complies with the requirement of natural selection—but he isolates it from the other individuals, and farther on, his chief occupation is the repeated application of the same principle in the separated stock of animals and their descendants, namely, the selection only of individuals answering his wishes. This action corresponds exactly to natural selection in isolated localities. Thus the breeder clearly unites two different actions. (1) The selection of particular individuals possessing certain desired characters corresponds to natural selection. But the breeder cannot, or cannot completely, destroy the rejected remainder. (2) Accordingly he directs his chief attention to the isolation of the selected material, in order to secure control over the true breeding in subsequent generations. Since the organisms kept under domestication are mostly amphimixotic,* the breeder must exclude especially the possibility of interbreeding with the outsiders. This latter point, although clearly understood by Darwin† himself, has been overlooked generally. It was forgotten, that beside the material used for breeding, there exists other "raw" material, and that the preservation of the latter constitutes a very important difference from

* As regards the origin of races as well as of species, it matters nothing, whether the respective organism is amphimixotic or not (see *Grundzüge*, etc., p. 32). Amphimixis, that is to say propagation by crossing effects equality, the fusion of different characters, and *not*, as Weismann asserts, the appearance of new variations. This law is not only logically evident, but is amply demonstrated by facts. Comp. Darwin, *Variation of Animals and Plants under Domestication*, 2d ed., ii, 1876, p. 62ff., where numerous examples of the equalizing power of crossing are recorded. This question is to be looked upon as finally settled already by Darwin and no doubt in the most convincing manner, namely, by well-established facts. It is extremely unintelligible how Weismann could throw aside all the proofs carefully collected by Darwin and substitute his own ill-founded conception of Amphimixis. I may add here that between the action of Amphimixis and that of Panmixia as accepted by Weismann, there exists a grave logical error. Amphimixis is the simple process of crossing occurring but once, Panmixia is the same process repeated often and in different directions: the effects of both can only differ in quantity. According to Weismann, however, Amphimix of different animals results in new differences, Panmixia of different animals in the disappearance of existing differences (variations without value for selection are absorbed). This remains an insurmountable contradiction until Weismann demonstrates that his Amphimixis and Panmixia are conceptions contradictory to each other. Eimer (*Entstehung der Arten*, i, 1888, p. 48) says, Amphimixis may produce new things by uniting different things. That is true in so far as the offspring is different from either parent. But this is the first step in uniting the characters of the parents. *The single individuals resulting from the same or similar crossings are more alike to each other than the parents were to each other.*

† Darwin (*Variation under Domestic.*, ii, p. 62) says: "The prevention of free crossing, and the intentional matching of individual animals, are the cornerstones of the breeder's art," and "No man in his senses would expect to improve or modify a breed . . . unless he separated his animals."

the process of natural selection, where such a remnant corresponding to the "raw" material does not survive—unless a *separation* by natural conditions is added.

III. The principle of *Separation* or *Isolation*, first conceived by M. Wagner, is considered by nearly all authors* as a factor of minor importance, although nearly all have conceded, that its occasional action cannot be denied. It was looked upon as an additional factor now and then favoring the formation of species, but not as a necessary one. In the original theory of Darwin isolation is not contained as a particular factor, although Darwin recognized the value of it very well, but he understood it in a purely geographical sense.† As regards the formation of different species he believes‡ it to be explained by the *principle of divergence:* divergence is useful, and if there are any divergent variations within one species, he says (p. 87): "They will be better enabled to seize on many and widely diversified places in the polity of nature, and so be enabled to increase in numbers." The introduction of this principle, however, is a mere circumlocution of "differentiation of species," not an explanation: we want to know, what are the *causes* of the divergence? If we peruse Darwin's writings in this respect, we find that he was very near to recognizing that separation actually effects the divergence,§ but since he understood separation only in a strictly geographical sense, he failed to put this factor in its proper place. Darwin's principle of divergence is nothing else than the result of separation, and if we substitute the latter for the former we shall complete Darwin's theory in a very important point.

Even Wagner, in introducing the principle of separation, did not give it its correct place within Darwin's theory, but tried on the contrary to replace, at least partly, selection by separation, and farther, he conceived the latter almost entirely in a purely geographical sense. Besides, he laid much stress upon the prevention of the crossing of the separated groups of animals, which is not at all the chief peculiarity of the action of separation. So have all other authors‖ in discussing this principle. But as we have seen, separation acts chiefly in the line, *that each separated group is subject to different conditions of life, and that thus the variations, the directions of inheritance and natural selection become different.* It does not act, however, always in this manner, since separation is possible

* I am to mention that G. Baur is almost the only author who estimates correctly the value of this principle. See the references to his papers: *Grundzüge*, etc., p. 29, footnote, and *Science*, March 6, 1896, p. 361.

† *Origin of Species*, Chaps. xii and xiii.

‡ *Ibid.*, p. 86ff.

§ Darwin (*Origin of Species*, pp. 98–100) uses even the words "confined or peculiar stations," and "isolated stations." On p. 169 he answers the question: "How . . . . can a variety live side by side with the parent species?" by the following: "If both have become fitted for slightly different habits of life or conditions, they might live together" and "the more permanent varieties are generally found, as far as I can discover, inhabiting distinct stations."

‖ For example, Haeckel and Weismann: see *Grundzüge*, etc., p. 31, footnote.

without a change or differentiation of external conditions of life: then a differentiation of species does not result, but we shall have the same species in separated localities. We call such species "relicts" from a former continuous distribution.*

Eimer, although he appreciates the value of geographical separation, names other causes besides: but what he calls "genepistasis" and "kyesamechania" are nothing else than particular actions of separation.

But for a plain understanding we should examine Eimer's theories more closely.†

Eimer‡ defends the opinion that variations are caused by external conditions, but that variability is not an indefinite one, but that the variations are comparatively few, and take place only in distinct directions. There is, according to him, no "fortuitous" or "irregular" variability, but a variability in certain few and distinct lines: he calls this the principle of *Orthogenesis*, and believes that it is contrary to Darwin's alleged supposition of unlimited and "fortuitous" variability. I can hardly see that this difference from Darwin exists at all. It is true Darwin uses the words "indefinite variability," but certainly not in the sense as interpreted by Eimer ("zufällig," "regellos"). Darwin says:§ "All such changes of structure, whether extremely slight or strongly marked, which appear amongst many individuals living together, may be considered as the indefinite effects of the conditions of life on each individual organism, in nearly the same manner as a chill affects different men in an indefinite manner, according to their state of body constitution," etc. That is certainly not a variability subject to casuality, but a variability governed by external causes, which may differ only according to the disposition of the individuals, and this opinion, that "the nature of the organism and the nature of the conditions"‖ are connected in the formation of variations, is also upheld by Eimer.¶

Further, he lays much stress upon the fact that variability advances in a definite direction (orthogenesis), but, I think, he confounds here two actions, that of variation and that of inheritance. Orthogenesis is variation, which is transmitted, and which is accumulated by the repeated action of the *same* external causes upon a series of descendants. We can hardly decide, whether a variation tends to advance in a distinct direction, unless we see that again and again specimens vary in the same direction,

*_Grundzüge_, etc., p. 34 and p. 86.

†I go more into details here than seems perhaps necessary, because I consider Eimer's investigations as very important, especially as regards the facts collected. But we shall see that Eimer's views do not differ considerably from Darwin's, and that the chief differences are only differences of terminology.

‡Eimer, *Die Entstehung der Arten auf Grund von Vererbung erworbener Eigenschaften nach den Gesetzen organischen Wachsens*, i, 1888.

§ *Origin of Species*, p. 6.

‖ *Ibid.*, p. 6.

¶ Comp. *l. c.*, p. 5. Variation is effected by "Wechselwirkung zwischen der stofflichen Zusammensetzung des Körpers und äusseren Einflüssen."

and if we see the same variation present in different degrees in a large number of individuals, we have reason to suppose that inheritance plays a part, since the amount of change, if often inherited, must on the one hand increase, and since, on the other hand, the force of inheritance is generally different in each individual. Thus orthogenesis, variation in a distinct direction, is the result of the combined action of variation and inheritance: but it is perhaps advantageous to accept Eimer's term, because, as we have seen above, it is important as regards the transformation of species.

Orthogenesis results in series of variations consisting each of a number of individuals varying in the same direction but in a different degree: it unites the single variations into *varieties*, that is to say, into groups of animals showing the same tendency of variation. This grouping of variations into varieties is especially due to inheritance.

Eimer tries farther to find out the causes of the breaking up of any series of variations into *species*, and reaches the conclusion that species are formed when a certain group of individuals within a series "loses its connection with its other allies."* This breaking up of a series of variations in consequence of lost connection he calls "*genepistasis*."† Under this head come, according to him, *Geographical Separation*, *Halmatogenesis*, and *Kyesamechania*.‡

If we direct our attention to the general definition of "*genepistasis*" given by him, that it is the losing of connection of certain groups, we see at once that genepistasis is exactly the same as separation, and under the same head comes *kyesamechania*.§ The latter term means that a sexual crossing between animals of more or less different characters is rendered impossible by morphological or physiological causes. This impossibility of crossing is certainly not the first *cause* of difference, but it is the *result* of already existing differences produced by beginning separation, and as respects the formation of species, kyesamechania can never be a primary cause of the origin of different species, but it is the result of the beginning differentiation, and may develop an additional factor accelerating the process of specific differentiation.

As regards *Halmatogenesis*, which means the sudden appearance of any new variation, Eimer explains this process by correlation:‖ but this explanation is insufficient. If any character changes, other characters connected by correlation with it change also, but if the change of the first is slow, certainly the changes of the others are so also, and a sudden change of characters by correlation presumes a sudden change of the leading character. Thus correlation cannot explain halmatogenesis.

* See *l. c.*, p. 26: "Wenn . . . . eine Gruppe von Individuen . . . . auf irgend eine Weise die Verbindung mit den übrigen Verwandten verloren hat . . . . spricht man von Arten."

† See *l. c.*, p. 30ff.

‡ I cannot make out with certainty what Eimer thinks as to the logical relations of these terms to each other, but I hope I have quoted him correctly.

§ See Eimer, *Die Artbildung und Verwandtschaft bei den Schmetterlingen*, ii, 1895, p. 14ff.

‖ See *Entstehung*, etc., p. 53.

But we do not need this at all. Halmatogenesis is a well-known process of inheritance, and comes under different heads in that chapter. For example, accumulative inheritance (even orthogenesis) may effect a sudden rise of the degree of development of a certain character, or characters remaining latent during one or more generations may come suddenly into reappearance, or farther, atavism may effect the same. Halmatogenesis does not at all play a part in the breaking up of a "chain of organisms," but it takes part only in the formation of varieties.

Therefore, of Eimer's new terms, only *Genepistasis* and *Kyesamechania* may form different species, and both are nothing else than *Separation*, or as Eimer himself says: "the interruption of connection."

By this brief sketch of Eimer's views we see that there is no considerable difference from Darwin's theory,* except that he considers natural selection to be of minor importance. This is probably due to the fact that he has investigated chiefly characters not at all subject to natural selection. He forgets, however, that even upon animals provided with indifferent characters natural selection must necessarily act in order to maintain the good standard of all the other characters. All the principles introduced by Eimer: Orthogenesis and halmatogenesis as forming varieties in a distinct direction, genepistasis and kyesamechania as forming species, are only new words for old ideas, which indeed have been set forth already by Darwin. And farther, these new terms are mostly results of well-known laws and not the primary causes of the formation of varieties or species, and they do not give us a better knowledge than before of the respective processes, in some cases, indeed, they may even induce confusion.

As respects *separation* we have seen that Eimer considers it only as an additional† factor causing specific differentiation, but farther we have seen that his genepistasis is also separation. Like all the other authors he apparently has conceived separation only in a purely geographical sense. I have, however, demonstrated‡ that we are to conceive the term *separation* in a *bionomical* sense, that is to say, that any causes "effecting a permanent interruption of the bionomical continuity between certain groups come under the head of separation. Separation keeps particular groups permanently under particular conditions, and thus they are prevented from migrating from one station of definite conditions of life into others with other conditions."

* Eimer identifies Darwin's theory with the "Darwinism after Darwin" (comp. *Artbildung und Verwandtschaft bei Schmetterlingen*, ii, 1895, Preface, p. v), in supposing that Darwin's theory alleges that species are formed by natural selection. But we know that this is an entirely unwarranted imputation.

† See *Artbildung*, etc., 1895, p. 9. I should like here to point out an apparent error in Eimer's arguments for the origin of new species in the middle of the range of the original form: he says (*ibid.*, p. 11) that the group of *Papilio asterias* originated from amidst the province of distribution of the group of *P. machaon*. A glance at his tables (Pl. vi–viii), however, shows that this is not the case.

‡ See *Grundzüge*, etc., p. 81, and *Amer. Jour. Sci.*, p. 63, et seq., 1896.

This prevention of migration is very important. *Migration* (as understood by M. Wagner) is an accessory factor, often coöperating with separation, and often working against it. Each species, which originated in a limited area, tends to occupy other territories: it is a well-known fact that each animal form possesses its peculiar "means of dispersal," and by such means it migrates. Migrating species occupy new territories, which have either the same or slightly different conditions of life: in the latter case migration by itself may induce new variations in consequence of the slightly modified action of the external conditions of life. Further, migration is often slow, or only possible under peculiar circumstances, often it is accidental, and only a few individuals can transgress the original limits on rare occasions: then even migration acts as a means of separation. The few individuals occupying a new locality are afterwards practically separated from the original stock remaining in their native country, and thus they may develop separately into a different species, even in the case that immigration from the original stock is not altogether impossible, since any rare individuals of the latter, reaching the new colony from time to time, are soon absorbed by the new form and their characters disappear by the continuous crossing with the modified individuals and by the transforming power of the external conditions. Separation, however, is not always connected with migration: the original "centre of origin" of a species may be broken up again into parts, thus inducing the origin of new species, if the external conditions favor it.

Separation in any form may be more or less complete, and since between complete continuity and complete separation intermediate steps are interposed, also a complete differentiation of species is reached by degrees. This corresponds exactly with what we see in nature. We know of many groups, the species of which are very insufficiently limited and pass gradually into each other: in such cases the formation of species is not yet accomplished. It is an incomplete separation, if a species occupying a large area is divided into different varieties, which are locally more or less limited, and differ in most remote localities considerably, while in intermediate places intermediate forms are present. The distinct varieties on the most extreme limits of the range are certainly under different conditions of life, but in the intermediate area transitions are present: a complete differentiation of species is not yet reached here, and we have to regard these forms still as varieties.

Of course, it is possible, that nearly allied species, which originated separately, may occupy by migration the same territory and come into competition with each other. If their morphological and physiological peculiarities are not sufficiently fixed, there may result by hybridization a new species. But if the characters are well fixed by inheritance, especially if there is "kyesamechania," they may live together or the stronger may suppress the weaker. But I may safely say, that it is very improbable that two closely allied species ever lived precisely under the same conditions in the same locality. I refer in this respect to the example of four

species of the Derapod genus *Gelasimus* on the East African coast recorded by me.* These four species lived in a particular locality completely separated, although often only a few yards from each other, and a collector less careful would have put them all together in one jar. Yet as a rule collectors are well acquainted with the fact that particular species are to be sought for in particular localities.

IV. I may, I think, conclude. I have amply demonstrated that only *separation* can effect differentiation of species, and that all the principles created by other authors for this particular effect come under the head of separation, *i. e.*, the breaking up of a number of individuals into groups, each subject to particular conditions of life. Some authors, indeed, have not understood at all that the whole process ending in the formation of species is composed of a series of distinct factors, only the last of which is separation. But I wish to say here expressly that already Darwin conceived those different factors correctly, and distinguished them well according to their particular line of action. The only change of Darwin's views that I should like to propose is to substitute for his "principle of divergence" that of "separation." Besides, it would be well to conceive the term "Natural Selection" in a modified sense, as Pfeffer has proposed, and we have seen that there is some advantage in so doing. And farther, Eimer has pointed out that not all the characters of each animal form are subject to natural selection: there are many which do not bear on utility, but are indifferent in this respect. But since such characters are probably also due to the influence of external conditions, they may be transmitted and may increase, giving origin to a distinct direction of variation,† to a "mutation," which is independent of natural selection, and may be called by Eimer's term "Orthogenesis."

For the rest, the whole of Darwin's theory stands, and none of those "Darwinists after Darwin"—I venture to say—have been able to weaken any of his ideas in the least degree. Especially Weismann has not, since

*See *Grundzüge*, etc., p. 33, footnote. Compare also the following sentences of Petersen (*Det Videnskabelige Udbytte af Kanonbaadens Hauchs Togter*, 1893, p. 455): "Each species seems to be distributed according to certain rules, which . . . . can be brought in relation to one or several . . . . natural conditions," and (p. 457): "no species is found everywhere in our seas," and farther: F. Dahl, "Vergleichende Untersuchungen über die Lebensweise wirbelloser Aasfresser," *Sitz. Ber. Akad. Wiss. Berlin*, January, 1896, pp. 29, 30.

† Already Darwin holds the same opinion and concedes (*Origin of Species*, pp. 170, 171), that there are variations which appear to be of no service whatever to their possessors. This passage is the more interesting, since he talks of the "laws of growth," which are apparently identical with Eimer's "Gesetzen organischen Wachsens." Comp. farther, *ibid.*, p. 175: "When from the nature of the organism and of the conditions, modifications have been induced which are unimportant for the welfare of the species, they may be and apparently often have been transmitted . . . . to numerous . . . . descendants," and p. 176: "Morphological differences, which we consider as *unimportant* . . . . first appeared . . . . as fluctuating variations, which sooner or later became constant through the nature of the organism and the surrounding conditions." (In the last passage the word I have italicized stands originally as *important*, but according to the foregoing and following sentences this is no doubt a misprint)

it is now demonstrated by the ablest scientists explicitly,* and by many others incidentally, that his theories are without any proper foundation. As regards Eimer's theories, I have endeavored in the above to show, that the alleged opposition in certain points to Darwin does not exist, except as Eimer creates new scientific terms for old ideas, and as he does not distinguish properly between cause and effect.

To sum up, we have to distinguish *four factors*† accomplishing the diversity, development and differentiation into species of organic beings : we may call conveniently this whole process : ***origin of species.***

1. All organic beings *vary*. There exists an "inherent tendency to vary,"‡ but this tendency is manifested only by the influence of external causes upon the respective organism. The faculty of variation is an unlimited one,§ but the actual variation is limited, namely by the external conditions of life. Variations coming into existence are modifications "directly due to the physical conditions of life," which "in this sense are supposed not to be inherited."‖ *A variation is impossible without external conditions producing it.*

2. *These variations may be transmitted to descendants.*¶ Inheritance is due to the process of propagation, which may be either by *one* parent or by *two* parents (Amphimixis). By inheritance acquired characters are transmitted from the parent to the descendants, and thus the consanguinity becomes morphologically visible, and individuals of common descent are more closely connected by morphological characters with each other than with any other group of individuals. By inheritance the unsteady and temporary variations are transformed into *varieties*, that is to say, into groups of individuals having the same ancestors and resembling each other more or less.**

*I refer to the following names: Eimer, Haacke, Haeckel, O. Hertwig, Pfeffer, Romanes, Spencer, and others. I would especially mention O. Hertwig's book, *Zeit- und Streit-Fragen der Biologie*, Heft i, "Praeformation oder Epigenesis." I recommend this masterpiece of criticism for study, not only because it refutes completely Weismann's fantastic germ-plasma theory, but because the exposition of this theory given in that work is much more intelligible than that given by Weismann himself. In his latest paper ("Germinal Selection," pp. 282, 285 and 286) Weismann refers to Hertwig's criticism: but his remarks are entirely aside from the question, since they do not touch the chief point, and, partly (p. 282), attribute to Hertwig an opinion which the latter, according to his own express statement, did not entertain (see pp. 10 and 11 of Hertwig's book).

† See *Grundzüge*, etc., p. 32.

‡ Darwin, *Var. and Domes.*, p. 2.

§ Unless checked by inheritance!

‖ Darwin, *Orig.*, p. 33.

¶ The transmission of acquired characters is denied by many competent naturalists and cannot be regarded as demonstrated. In the problems of geographical distribution one is continually brought back to this as a probable assumption, and I propound it here as a "working hypothesis."

** Darwin, *Orig.*, p. 33: In "the term variety . . . . community of descent is . . . . implied."

The process of inheritance is most obscure.* We know nothing of the causes of inheritance or—perhaps it is better to say—of non-inheritance often occurring. Weismann's theory of inheritance, even if we accept it (as I do not), does not explain the essence of heredity: it merely refers inheritance to minute processes in fertilization. But this knowledge that heredity is due to the peculiarities in propagation is a very old one, as old as modern zoölogy and perhaps even older, and more accurate knowledge of the minute details in propagation, and their arbitrary augmentation by supposed complications does not promote our understanding of heredity. Yet we do not know how the "tendencies of inheritance" of the germs (or parts of the germs) are transferred to the "soma" of the descendants; we do not know how the germs get these "tendencies" from the "soma" of the parents; we do not know why certain "tendencies" become visible in the descendants, while others do not; we do not know what a "tendency of inheritance" is like anyhow.† A theory of inheritance has to endeavor to answer the questions put here, otherwise it does not explain anything, and the essence of heredity continues to be as obscure as before.

By inheritance and repeated action of particular external conditions a distinct direction of variation may be induced: certain animal forms tend again and again to vary in the same direction, and the degree of the variations is thus increased. This process is what Eimer calls orthogenesis, and if the action of the external conditions as well as of inheritance is not a steady one, but interrupted and irregular, we have his halmatogenesis. Both terms clearly come under the head of inheritance. Orthogenesis and halmatogenesis can effect "mutations," but we must bear in mind that here no principle of utility comes into play.

It is well to be noted that the two factors mentioned, variation and inheritance, act only upon single individuals. They act often upon a number of individuals in the same or analogous manner, but each individual can vary and inherit without regard to others. The two following principles (natural selection and separation) can only act upon a multitude of individuals simultaneously, and their action becomes conspicuous only by the comparison of many individuals.

3. Upon the material produced by variation and inheritance acts a third factor: *Natural Selection.* By this principle all variations injurious in the struggle for existence, all the forms not fitted for existence under a

*See Osborn ("The Hereditary Mechanism and the Search for the Unknown Factors of Evolution," *Biol. Lect. Mar. Biol. Lab.*, Wood's Holl, 1895): "If acquired variations are transmitted there must be some unknown principle in heredity."

†Of course, Weismann has tried to answer these questions, at least partly, by his "theories," but such questions cannot be explained at all by "theories," the very foundations of which are either disputable or arbitrary, or even illogical and contrary to the known facts. On the whole, Weismann's arguments run in a perfect *circulus vitiosus.* His theory of inheritance is founded upon the belief that acquired variations are not transmitted, and the demonstration, that acquired variations are not transmitted, is founded upon the belief that his theory is correct (comp. *Neue Gedanken zur Vererbungsfrage*, 1895, pp. 11 and 21).

certain sum of conditions of life are destroyed. The remnant left is fit for existence, and all the individuals surviving are able to live and propagate. There may be slight differences between them, especially as regards characters not bearing on utility, but a certain average of good characters is present. Natural selection at least preserves this good average, and if there arise any useful characters, a smaller percentage of the individuals possessing the latter is destroyed, and thus the better individuals may gain little by little the preponderance in number: the average is displaced slowly in a distinct direction, namely, toward the better. This latter "mutation" is distinguished from the mutation by orthogenesis by the advantage connected with the particular line in which the change advances. Natural selection effects a general adaptation of the whole number of the surviving individuals to particular conditions of life.

4. But natural selection does not form species; it only preserves or transforms already existing species. If we suppose, however, that of the individuals surviving in natural selection different groups are *separated* from each other under different conditions, and that this *separation* cannot be overcome, so that each group must remain under the constant action of particular conditions, the difference of the latter effects, that each group tends to develop its characters in a different direction. It is true, if upon each separated group the same external conditions act in the same manner, there would be, of course, no separation of the directions of development. But differentiation of the external conditions by bionomic separation, and the splitting into groups of individuals living formerly under the same conditions will give origin to different characters in each group, and animals distinguished by the constant presence of different characters we call *species. Different species are formed by bionomic separation; separation does not always imply differentiation of the conditions of life, and accordingly does not always form new species; but if there is a differentiation into species, it is always due to separation under different bionomic conditions.*

In the above the particular action of each of the four chief factors playing a part in the evolution and diversification of the organic world is properly limited. We have seen that the two last-named factors, selection and separation, are imitated by man in the breeding of domesticated animals. Both nature and man use the material furnished by variation, and the success of both is warranted under the condition that the acquired characters may be fixed by hereditary transmission. The four factors named, *variation, inheritance, selection* and *separation*, must work together, in order to obtain different species, and, indeed, they do so always; it is impossible to think that one of them should work by itself, or that one could be left aside.

The proper action of each of these factors was recognized almost correctly by Darwin, only as respects the differentiation of species, which he attributes to the principle of divergence, he was not quite satisfied.* But

* Darwin, *Origin*, p. 87: "Though it was a long time before I saw how."

most of the successors of Darwin, especially those who pretended to have modified, corrected or enlarged his views in any respect, have not understood his theory correctly: generally the origin of variations, varieties and species has been hopelessly confused, and the latter is especially true of the writings of Weismann, in which the origin of species and varieties, and the origin of the adaptive characters of life are mixed up constantly.*

In, conclusion I should like to add that the principle of separation, as set forth above, bears very importantly on the definition of the systematic term *Species*, and indeed, that it alone enables us to give a correct definition of it. There is no doubt that a proper and logical definition of any term depends largely on the knowledge of the genesis of the object, and in the present case we may say that if the process of the formation of species is properly understood, we can derive from this knowledge a definition of the term species. In my book often above referred to, I have propounded the following:† "*We designate as* SPECIES *such forms as in consequence of* SEPARATION *differ sharply and constantly by morphological characters from allied coëxisting forms.*" It is not necessary that separation should be still evident in all the existing species: the separating causes have often disappeared, while their result, the different species, still exist. But then the separation in the past must have been sufficient to modify and differentiate the respective forms in such a degree that the characters are fixed by inheritance, so that changed external conditions cannot influence them again, and farther, there must be kyesamechania, which prevents hybridization. The possibility, however, of hybridization by artificial means cannot be always regarded as a proof against the value of the respective forms as species: if two species live separated they do not interbreed in nature, and if they are forced to do so, this possibility cannot affect their value as species under normal and natural conditions.

As separation is reached by degrees, distinct species must have developed gradually, and such must still develop. We know numerous examples of so-called "polymorphous" genera, where apparently the process of formation of species is beginning or not yet accomplished. It is true, variations, varieties, and species pass gradually into each other, but this does not imply that these three terms shall be treated alike, and that there is no difference at all between them. A tree is not a shrub, although there are intermediate growths. So we can give a correct definition of variety and species, although there are intermediate forms, which may be doubted, whether they belong to the one or the other.

* This confusion of Weismann's ideas is most evident in the two last pages of his latest publication ("Germinal Selection," *The Monist*, Vol. 6, No. 2, January, 1896, pp. 292, 293). This whole paper is devoted to the demonstration of the action of natural selection as effecting *adaptation*, and though he says that "the mode of formation of the living world as a whole" may be understood by this principle!

† See *l. c.*, p. 32.

The principle of *constant difference* is practically applied generally by systematists, and I hope I have given above a logical foundation of this principle. In many cases, indeed, the constancy of difference is the only means by which species can be distinguished, if the former or the actual separation of the respective forms cannot be made out with certainty. But in all cases, where an actual separation is evident, we should consider the respective forms, if morphologically distinct, as species, not as varieties. Under the new definition of the term species given here, many of the so-called local varieties become species, since such are often distinguished only because the differences from "good" species are only slight ones and are not considered as important enough to create a distinct species. But this standpoint is not correct: any difference in characters, however slight, constitutes a distinct species, if constant and due to separation.

PROCEEDINGS

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HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

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EXTRACT FROM THE LAWS.

CHAPTER XII.

OF THE MAGELLANIC FUND.

SECTION 1. John Hyacinth de Magellan, in London, having in the year 1786 offered to the Society, as a donation, the sum of two hundred guineas, to be by them vested in a secure and permanent fund, to the end that the interest arising therefrom should be annually disposed of in premiums, to be adjudged by them to the author of the best discovery, or most useful invention, relating to Navigation, Astronomy, or Natural Philosophy (mere natural history only excepted); and the Society having accepted of the above donation, they hereby publish the conditions, prescribed by the donor and agreed to by the Society, upon which the said annual premiums will be awarded.

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1. The candidate shall send his discovery, invention or improvement, addressed to the President, or one of the Vice-Presidents of the Society, free of postage or other charges; and shall distinguish his performance by some motto, device, or other signature, at his pleasure. Together with his discovery, invention, or improvement, he shall also send a sealed letter containing the same motto, device, or signature, and subscribed with the real name and place of residence of the author.

2. Persons of any nation, sect or denomination whatever, shall be admitted as candidates for this premium.

3. No discovery, invention or improvement shall be entitled to this premium, which hath been already published, or for which the author hath been publicly rewarded elsewhere.

4. The candidate shall communicate his discovery, invention or improvement, either in the English, French, German, or Latin language.

5. All such communications shall be publicly read or exhibited to the Society at some stated meeting, not less than one month previous to the day of adjudication, and shall at all times be open to the inspection of such members as shall desire it. But no member shall carry home with

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Stated Meeting, September 4, 1896.

Curator, Dr. J. C. MORRIS, in the Chair.

Present, 9 members.

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Letter declining membership from T. Mitchell Prudden, New York, N. Y.

An invitation from the President of the Société Physico-Mathématique de Kasan, Russia, to the inauguration of a monument to perpetuate the memory of N. J. Lobatchefsky, the celebrated Russian geometrician, to take place September 13, 1896.

A circular letter from Général-Major M. Rykatchew, announcing his election by the Académie Impériale des Sciences, St. Petersburg, Russia, to the post of Directeur of the Observatoire Physique Central de St. Petersburg.

Letters of envoy from the Geological Survey of India, Calcutta; Naturforscher-Gesellschaft, Dorpat, Russia; Musée Teyler, Harlem, Holland; Maatschappij der Nederlandsche Letterkunde, Leiden, N. Holland; Académie R. des Sciences, Stockholm, Sweden; Naturforschende Verein, Brünn, Austria; K. Geologische Landesanstalt und Bergakademie, Berlin, Prussia; Naturwissenschaftliche Verein für Schleswig-Holstein, Kiel, Prussia; Württembergische Verein für Handelsgeographie, Stuttgart; R. Accademia di Scienze, Lettere ed Arti, Modena, Italy; Faculté des Sciences, Marseilles, France; Société Philologique, Bureau des Longitudes, Paris, France; Zoölogical Society of London, Meteorological Office, London, Eng.; Radcliffe Observatory, Oxford, Eng.; Royal Dublin Society, Royal Irish Academy, Dublin, Ireland; Mr. T. W. Higginson, Dublin, N. H.; Meteorological Observatory, New York, N. Y.; U. S. Department of Agriculture, Bureau of American Ethnology, U. S. Coast and Geodetic Survey, Washington, D. C.; Agricultural Experiment Stations, Madison, Wis., St. Anthony Park, Minn., Brookings, S. Dak.; Museo Nacional, Buenos Aires, S. A.; Instituto Fisico-Geografico Nacional, San José de Costa Rica, C. A.

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sophical Society, Belfast, Ireland (149); R. Dublin Society, Dublin, Ireland (149); Royal Society (149), Prof. J. Geikie (149), Royal Observatory, Edinburgh, Scotland (147–149); Geological Society, Glasgow, Scotland (149); Public Library, Boston, Mass. (149); Drs. Henry Hartshorne, Samuel P. Sadtler, Philadelphia (149); Wisconsin Academy of Science, etc., Madison (148, 149); Museo Nacional, Buenos Aires, S. A. (148, 149); Museo de la Plata, La Plata, S. A. (143, 146, 147); Société Scientifique du Chili, Santiago (147–149); M. E. im Thurn, British Guiana, S. A. (148); Agricultural Experiment Stations, New Haven, Conn. (149), Knoxville, Tenn. (149), Manhattan, Kans. (149), St. Anthony Park, Minn. (138–141).

Accessions to the Library were reported from the Société de Géographie, Alger, Africa; South African Philosophical Society, Cape Town; Observatory, Adelaide, Australia; R. Geographical Society, Melbourne, Australia; Tokyo Library, Tokyo, Japan; Observatory, Madras, India; Société Roumaine de Géographie, Bukarest; M. Enzio Reuter, Helsingfors, Finland; Naturforscher Gesellschaft, Dorpat, Russia; Naturforscher Verein, Riga, Russia; Société de Geographie, St. Petersburg, Russia; K. Nordiske Oldskrift Selskab, Lieut.-Col. Axel Staggemeier, Copenhagen, Denmark; K. Svenska Vetenskaps Academie, Stockholm, Sweden; Musée Teyler, Harlem, Holland; Nederlandsche Letterkunde Maatschappij, Leiden, Holland; K. Bibliotheek, 's Gravenhage, Z. Holland; Société Entomologique de Belgique, Société Belge de Géologie, de Paléontologie, etc., Bruxelles, Belgique; Naturforschender Verein, Brünn, Austria; Siebenbürgische Verein f. Naturwissenschaften, Hormannstadt, Austria; Naturhistorische Landes-Museum in Kärnten, Klagenfurth; K. K. Sternwarte, K. B. Gesellschaft d. Wissenschaften, Prag, Bohemia; I. R. Accademia degli Agiati, Roveredo, Tyrol; K. K. Central Anstalt f. Meteorologie, K. B. Gesellschaft d. Wissenschaften, Vienna, Austria; Physikalische-Technische Reichsanstalt, K. P. Geologische Landesanstalt, Physiologische Gesellschaft, Association Géodésique Internationale, etc., Berlin, Prussia; Naturwissenschaft-

liche Verein, Bremen, Germany; Naturwissenschaftliche Gesellschaft "Isis," Dresden, Saxony; Verein f. die Geschichte und Alterthumskunde, Erfurt, Prussia; Verein f. Geographie und Statistik, Frankfurt a. M., Germany; Naturwissenschaften Verein f. d. Reg. Bez., Frankfurt a. O., Prussia; Verein der Freunde der Naturgeschichte in Mecklenburg, Güstrow; Naturwissenschaftliche Verein f. Schleswig-Holstein, Kiel, Prussia; Institut Grand-Ducal, Luxembourg, Germany; Bayerische Botanische Gesellschaft, München; Württembergische Verein f. Handelsgeographie, Stuttgart; Verein f. Kunst und Alterthum, Ulm, Württemberg; Mittelschweizerische Geographisch-Commercielle Gesellschaft, Aarau, Switzerland; Geographische Gesellschaft, Berne, Switzerland; Société Vaudoise des Sciences Naturelles, Lausanne, Switzerland; Société Neuchateloise de Geographie, Neuchatel, Switzerland; Naturwissenschaftliche Gesellschaft, St. Gall, Switzerland; Naturforschende Gesellschaft, Zurich, Switzerland; R. Instituto di Studi Superiori, Practice, etc., Firenze, Italia; Società Toscana di Scienze Naturali, Pisa, Italy; R. Comitato Geologico d'Italia, Roma; R. Accademia delle Scienze, Torino, Italia; R. Instituto Veneto di Scienze, etc., Venice, Italy; Société Linnéene, Bordeaux, France; Académie N. des Sciences, Caen, France; Société d'Histoire et d'Archéologie, Chalon-sur-Saone, France; Université de Lyon, Lyon, France; Société de Physique, Bureau des Longitudes, Société Philologique, Société Zoologique de France, Société de Geographie, Ministère de l'Instruction Publique, Paris, France; Cambridge University, Cambridge, Eng.; R. Cornwall Polytechnic Society, Falmouth, Eng.; Royal Institution of Great Britain, Victoria Institute, London, Eng.; Radcliffe Observatory, Oxford, Eng.; R. Irish Academy, R. Dublin Society, Observatory of Trinity College, Dublin, Ireland; N. S. Institute of Science, Halifax; Natural History Society, Montreal, Canada; Society of Natural History, Boston, Mass.; Peabody Museum, Mr. T. H. Higginson, Cambridge, Mass.; American Association for Advancement of Science, Salem, Mass.;

R. I. Historical Society, Dr. Albert Leffingwell, Providence, R. I.; Connecticut Historical Society, Hartford; Yale University, New Haven, Conn.; Brooklyn Library, Brooklyn, N. Y.; Buffalo Library, Historical Society, Buffalo, N. Y.; Historical Society, Academy of Sciences, Mr. Thomas A. Davies, New York; Geological Society of America, Academy of Sciences, Rochester, N. Y.; Rev. Thomas C. Porter, Easton, Pa.; Pennsylvania Geological Survey, Harrisburg, Pa.; Wagner Free Institute, Protestant Episcopal Diocese of Pennsylvania, American Medical Association, Drs. D. G. Brinton, Persifor Frazer, Charles A. Oliver, Messrs. John F. Lewis, Julius F. Sachse, Philadelphia; American Historical Association, U. S. Fish Commission, U. S. Coast and Geodetic Survey, U. S. Department of Agriculture, Bureau of Ethnology, Washington, D. C.; Tulane University of Louisiana, New Orleans; Missouri Botanical Garden, St. Louis; Iowa Geological Survey, Des Moines; State University of Iowa, Iowa City; University of California, Sacramento; Kansas Historical Society, Kansas Academy of Sciences, Topeka; University of Wyoming, Laramie; Rt. Rev. Bishop Crescencio Carrello, Merida, Yucatan; Instituto Medico Nacional, Mexico, Mex.; Museo Nacional, Oficina Meteorológica Argentina, Buenos Aires, S. A.; Société Scientifique du Chili, Santiago; Instituto Fisico-Geografico N. San José de Costa Rica, C. A.; Museo Paulista, S. Paulo, C. A.; Agricultural Experiment Stations, Burlington, Vt., New Haven, Conn., Storrs, Conn., Blacksburg, Va., Raleigh, N. C., Lincoln, Neb., Las Cruces, N. M.

A photograph for the Society's album from Dr. P. Topinard, Paris, France.

The following deaths were announced:

Prof. Dr. Ernest Curtius, Berlin, Prussia, July 11, 1896.

Prof. Gabriel Auguste Daubrée, Paris, France, May 29, 1896, æt. 81.

Prof. Abel Hovelacque, Paris, France.

Sir William Robert Grove, London, Eng., August 2, 1896, æt. 85.

Sir Joseph Prestwich, Shoreham, near Sevenoaks, Kent, Eng., June 25, 1896.

Prof. Josiah D. Whitney, Cambridge, Mass., August 19, 1896, æt. 77.

Mr. Lewis A. Scott, Philadelphia, August 11, 1896, æt. 77.

Mr. Henry D. Wireman, Philadelphia, May 30, 1896, æt. 50.

Prof. Hubert Anson Newton, New Haven, Conn., August 12, 1896, æt. 66.

The President was requested to appoint members to prepare obituaries of L. A. Scott, H. D. Wireman and Gabriel Auguste Daubrée.

A letter from Prof. Branner was read transmitting a paper on the "Marine Fossils of the Coal Measures of Arkansas," by Dr. J. P. Smith.

On motion the paper was referred to a committee for examination and report.

Pending nominations 1332, 1334, 1357, and new nominations 1358 and 1359 were read.

On motion of Mr. Tatham, the President was requested to appoint a representative of this Society at the International Congress of Geologists, to be held in St. Petersburg, Russia, in 1897.

On motion, Dr. D. G. Brinton was appointed the representative of this Society at the International Congress of Americanists in Havre in 1897.

The rough minutes were read and approved, and the meeting adjourned by the presiding member.

Stated Meeting, September 18, 1896.

Curator, Dr. J. C. Morris, in the Chair.

Present, 9 members.

Correspondence was submitted as follows:

From the President, appointing Messrs. Cope, Lyman and

Prime a Committee to examine the paper on "The Fossils of the Coal Measures of Arkansas;" Dr. G. R. Morehouse to prepare an obituary of L. A. Scott; Prof. J. P. Lesley that of Gabriel Aug. Daubrée.

Dr. Frazer was appointed to represent this Society at the International Congress of Geologists to be held in St. Petersburg in 1897.

Letters of envoy from the Académie R. Suédoise des Sciences, Stockholm; Soc. R. de Géographie, Anvers, Belgique; Johns Hopkins University, Baltimore, Md.

Letters of acknowledgment from the Royal Society of N. S. W., Sydney (148, 149); Public Library, Wellington, New Zealand (148, 149); Geological Survey of India, Calcutta (149); Hungarian Academy of Science, Budapest (143, 146–149); K. K. Sternwarte, Prag, Bohemia (149); Gesellschaft für Erdkunde, Berlin, Prussia (149); Library of Bonn, Prussia (149); Geographical and Statistical Soc., Frankfurt a. M. (143–146, 149); K. Leop. Carol. Akademie, Halle a. S. (149); Kolonial Museum, Haarlem, Holland (149); Verein f. Thüringische Geschichte u. Alterthums, Jena, Germany (149); Phys. Okon. Gesell., Königsberg (148); R. Instituto di Studi Superiori, Firenze, Italia (148, 149); Prof. E. Levasseur (148, 149), Marquis de Nadaillac, Paris, France (149); Meteorological Office, London, Eng. (149); Prof. A. Agassiz, Cambridge, Mass. (149).

Accessions to the library were reported from the Observatoire Impérial, Constantinople, Turkey; Anthropological Society, Tokyo, Japan; Ponasang Missionary Hospital, Foochow, China; Dr. Aristides Brezina, Vienna, Austria; K. P. Meteorologische Institut, Berlin; Mr. A. C. Tannert, Neisse, Prussia; Physikalisch-Oekonomische Gesellschaft, Königsberg, Prussia; R. Accademia di Belle Arti, Milan, Italy; Institut International de Statistique, Rome, Italy; Ministre des Travaux Publics, Dr. E. T. Hamy, Paris, France; R. Academia di Ciencias y Artes, Barcelona, Spain; Linnean Society, Cobden Club, Meteorological Office, London, Eng.; Université Laval, Quebec; Mr. Wharton Barker,

Prof. E. D. Cope, Philadelphia; Commissioner of Labor, Washington, D. C.; Ohio Archæological and Historical Society, Columbus; Society of Natural History, Cincinnati, O.

The death of Prof. G. Brown Goode, Director of the U. S. National Museum, Washington, D. C., September 6, 1896, æt. 46, was announced.

Dr. Brinton read a paper on the "Vocabulary of the Noanama Dialect of the Choco Stock."

Dr. Horn spoke of the difficulties of reporting these unwritten dialects owing to the absence of a standard of pronunciation. He also adverted to the evident use of the "r" sound, which was absent in the Indian dialects of western America.

Dr. Frazer suggested the use of the symbols made by the phonographic stylus, as he had described them in a paper read before this Society, April 5, 1878.

Pending nominations 1332, 1334, 1357, 1358, 1359 and new nominations 1360 and 1361 were read.

The rough minutes were read and approved, and the Society adjourned by the presiding member.

Vocabulary of the Noanama Dialect of the Choco Stock.

By Daniel G. Brinton, M.D.

(Read before the American Philosophical Society, Sept. 18, 1896).

In the *Proceedings* of this Society for November last (Vol. xxxiv, pp. 401, 402), I presented a short vocabulary of the Andagueda dialect of the Choco stock, obtained by Mr. Henry Gregory Granger on the upper waters of the Atrato river, Colombia, South America.

During the summer of the present year, Mr. Granger visited the west coast of Colombia, and at the mouth of the river San Juan (N. lat. 5°) met a tribe of about fifty Indians, who spoke an idiom, said not to be understood by those of the interior or the other coast tribes. They are still rather primitive in culture and have the peculiarity of piercing their ears to form apertures about half an inch in diameter, in which they insert bunches of sweet-smelling herbs.

Mr. Granger took occasion of an enforced delay at their hamlet to collect some words of their language, which he sent me for examination. On comparison it proves to be a dialect of the Choco stock, evidently the Noanama, that being the name of the tribe which, in recent years, was located on the upper waters of the Rio San Juan.

The statement that it is unintelligible to their neighbors need cause no surprise, as this is apt to be asserted of closely related dialects of the same family. From this habit, the old writers were accustomed to believe that in America, especially South America, as Cieza de Leon averred, each day's journey brought them into a totally different language. In fact, the modern studies of South American tongues are rapidly diminishing the linguistic stocks of that continental area. This vocabulary is valuable, therefore, not only for itself but as dispelling another delusion of this nature.

Man,	*emcōydăh.*
Woman,	*ōoĕdah.*
Sun,	*ehdōw.*
Fire,	*eggdŏw.*
Water,	*daugh.*
Head,	*pŏrŏ.*
Eye,	*dow* (as English "now").
Ear,	*kătchee.*
Mouth,	*e* (as in English).
Nose,	*kayohm* (in one syllable).
Tongue,	*mayungkŭnah.*
Teeth,	*kuyēhrăh.*
Hand,	*hooah.*
Foot,	*beu* (as in French *beurre*).
House,	*dee.*
Boy,	*emcōydŭm.*
Girl,	*ooedŭm.*
Hot,	*paitchkĕ.*
Cold,	*nemheitchaga.*
Day,	*assdōwwah.*
Night,	*ehdarrah.*
Fish,	*kŭoorah.*
Sea,	*pwassah* (the *pw* as very nasal).
Canoe,	*happakkah.*

Comments.

Man, Woman.—In all the Choco dialects these are compound words, having the same second element (*eda*, *era*, *ena*, *ira*), which

must be generic for "human being," preceded by an element indicating sex, *emu* (*emo*, *umu*, *'mu*, *uma*, *im*) for the masculine, and *ue* (*ui*, *aue*) for the feminine. These have analogies in neighboring stocks. The words for *boy* and *girl*, given above, are the same as for *man* and *woman*, with a suffixed *m*, indicating diminutive size (*dŭm* = *dăh-m*).

Sun, *Moon*.—Mr. Granger does not give the word for *moon*, but other vocabularies show that it is the same as for sun, *edau*, the distinction being made by adding *night*, or some such term. This is common in American languages. The similarity between the words for *sun* and *fire* is accidental, and is not borne out by other dialects of the stock.

Water.—The word given *daugh* (otherwise *do*) properly means "river." The Choco word for water in general is *pania*.

Tongue.—Other vocabularies give *meuhina*.

Foot.—Another vocabulary gives *bo-pidi*. The first syllable is evidently identical.

Day, *Night*.—Evidently compounds, the second element *dowwah* or *darrah* being the same, the prefixes *ass* and *eh* (or probably *ehd*) distinguishing the concepts. The latter seems to be the same as in *ehdow*, sun or moon.

Sea.—This is the usual Choco word, *puscha*.

Canoe.—The Choco term is *hampua*, of which *happakah* is probably a variant.

The words given for *hot*, *cold*, *fish*, are those not found in my vocabularies of other dialects. They may be synonyms or borrowed expressions.

The numerals, as given by Mr. Granger, are:

One,	*aambah.*
Two,	*noome.*
Three,	*tanhoopah.*
Four,	*hayyăppah.*
Five,	*hwambah.*
Ten,	*hwapputumah.*
Twenty,	*orrmŏnambah.*
Thirty,	*orrmŏnabharrah.*
Forty,	*orrmŏnnoomĕ.*

The system is evidently vigesimal; *orrmon-ambah* = one twenty, 20×1; *orrmon-noome*, 20×2, etc. In the usual Choco it is quinary, as *tua soma*, 5; *ome juá soma*, $2 \times 5 = 10$; *guimane jua soma*, $4 \times 5 = 20$, etc.

On the Second Abdominal Segment in a Few Libellulidæ.

By Martha Freeman Goddard.

(*Read before the American Philosophical Society, October 2, 1896*)

In the spring of 1892, I made, in connection with my work in the zoölogical department in Wellesley College, a somewhat careful study of the second abdominal segment and the penis in a few male Libellulinæ. Though I was unable to do all that I had planned, it seems worth while to publish my results in spite of their fragmentariness, since they may serve as a basis for the work of some one else.

I wished to learn the details of external structure in this part of the body and to determine as far as possible the homologies of the various parts. The species studied were *Diplax rubicundula* and *vicina; Celithemis elisa; Libellula pulchella, quadrupla* and *exusta; Plathemis trimaculata.* I will begin by a full description of *Diplax rubicundula,* and then follow this by a brief statement of the more important respects in which the other species studied differ from this one.

The second abdominal segment, like most of the others, consists of a narrow ventral piece, and a broad dorsal piece covering both back and sides of abdomen. The first is the sternum; the second, the tergum. The tergum (Fig. 1) is made up of three sclerites which form a longitudinal series. The suture between the first and the second is present only on the dorsal half of the segment, becoming obsolete as it approaches the sides; that between the second and third is distinct for its entire extent. Each side of the second sclerite is produced caudolaterally into a rounded process called the genital lobe (*a*). The third sclerite is shorter than either of the others; it ends abruptly at the base of genital lobe. The sternum (*e*, Fig. 2) consists of but one sclerite. This is nearly as long as the first tergal one and lies ventrad of it, the cephalic edge a little caudad of the cephalic edge of the tergum. The cephalo-lateral angles are produced into wing-like processes (*f*) which underlie the tergum and serve for the attachment of muscles. Caudad of the sternum is a long extent of membrane which lies ventrad of the caudal part of the tergum, and where it meets the sternum is so infolded as to make a recess over which the latter projects like a pent-house roof. Indeed, except at its very cephalic edge, the whole sternum bulges out to a greater or less degree from the rest of the segment.

On the membranous surface directly caudad of the sternum lie a pair of stout appendages (*g*) called hamules, readily to be seen with the naked eyes. Each is a thick, laterally compressed and somewhat elongated organ which is cleft distally into two divisions; a short, strong spur ending in an incurved, strongly chitinized tip (*h*), and a truncate shorter portion (*i*) having the face turned towards the spur concave. The hamule projects ventrad and the lobes lie cephalad and caudad; the

truncate lobe is the more caudal. The divisions vary greatly in length and shape in different species, though they generally form, as in *Diplax rubicundula*, about one-third of the length of the entire appendage. From the point of bifurcation, a ridge extends for a considerable distance towards the base of the hamule. The mesal face of the organ is largely membranous, especially at the base, so that the hamule can be flexed freely towards its fellow of the opposite side.

The hamules are borne by a chitinous framework (*k*), in shape roughly resembling a U, and attached by its tips to the inner face of the ventral sclerite. It seems to arise as a local chitinization of the membrane which lies caudad of this sclerite. Projecting from either side of the framework just caudad of the sclerite is a short rod (*m*) to which is attached one of the hamules. On the median part of the framework is borne a triangle (Fig. 3, *n*). Its apex points cephalad; its cephalolateral sides are chitinized, though elsewhere it is membranous; and its base projects more or less caudad of the frramework. The basal angle of either side forms a second, posterior point of attachment for the hamule of that side.

Another conspicuous structure is attached just caudad of the framework on the median line (Fig. 2). When extended as in the diagram. its tip points cephalad, but the distal end is ordinarily flexed upon the proximal part. The organ consists of an enlarged basal portion, the genital bladder, and of a slender, rodlike distal part, the penis. The genital bladder is a somewhat hemispherical body. The caudal half of its dorsal surface is attached for nearly its entire width to the underlying part of the abdomen and the rest of the dorsal face is chitinized. The ventral face is imperfectly chitinized, the chitin being deposited in three triangles; a median caudal one (*w*) and two cephalo-lateral ones (*o* and *r*), all separated from one another by band-like membranous interspaces, which, evidently, afford opportunity for variations in the size of the bladder. This mode of attachment of the bladder causes the structure of which it constitutes the base to appear as an appendage of the second segment; it does really, however, belong to the third, as is clearly seen in *Celithemis elisa*.

The penis consists of three segments; the first two are very simple, but the third is extremely complicated. The first is chitinized continuously on its dorsal surface, but the second, though in the main chitinous on this aspect, is membranous on the dorso-mesal line. Both are membranous ventrally and this condition is evidently correlated with the fact that in the position of rest this portion is covered by the reflexed tip of the penis. What we have called the third segment consists of two entirely distinct sclerites and of a cluster of appendages, some membranous and some chitinous, borne at the extreme tip of the organ. The larger and more proximal sclerite (1) constitutes the dorsal aspect of the segment. It is somewhat shield-shaped, but the distal angles are prolonged and curved around to the ventral side where they almost meet.

For convenience we shall term it the shield. When the penis is flexed, the distal part is protected by the overlying hamules so that this sclerite is the only portion exposed. The point of flexion is just proximad of it, which accounts for its very limited extent on the ventral aspect. The second sclerite (2) is narrower than the first, is irregularly ring-shaped and lies just distad of the shield. We shall call this the ring. As will be seen later, it encircles most but not all the divisions of the penis-tip. Distad of the ring on the dorso-mesal line is a chitinized body (5), which divides into slender, tapering horns; it is recognizable by its honey-yellow color and we shall call it the fork. Arising from nearly the same place are two membranous lobes (4), with transverse rows of closely set chitinous hairs. These may be contracted into roundish masses which, because of the brown hair, seem on first appearance to be chitinized. When extended, as in the plate, they appear bannerlike, and we shall term them the banners. Near the base of each is a small cluster of long, stout bristles. Laterad of the banners are two blunt lobes (6), somewhat membranous proximally but strongly chitinized toward their distal end. As these are in many species somewhat twisted, we have termed them the twists. Pressure on the genital bladder causes them to rotate laterad and ventrad; they may possibly serve, therefore, to retain the hold of the penis-tip within the vulva. Ventrad of all the others lies a large, membranous lobe which somewhat resembles the shape of a monk's hood and which we have called the hood (3). With a view to possible homologies it is well to note the relative position of these structures. The penis viewed from the tip presents a depression or pit guarded above by the fork, below by the hood, laterad by the banners and these again are guarded laterad by the twists. The ring lies entirely dorsad of the hood and does not encircle it. According to Rathke, there is in *L. ænea* a minute opening at the penis-tip.

In *Diplax vicina*, the ventral sclerite is deeply emarginate, and its caudo-lateral angles are strongly chitinized. The hamules are small and inconspicuous (Fig. 5, *g*). The basal portion is short and the two lobes are of about equal length. The tip of the anterior lobe is strongly chitinized and very markedly incurved.

The last division of the penis consists of but one sclerite in addition to the cluster of appendages at the tip. This sclerite is long on the dorsal and short on the ventral aspect, where its edges nearly but not quite meet. Its general shape would seem to indicate that it is formed by the fusion of the shield and ring; moreover it bears a pair of short transverse ridges which look like the indications of such fusion. But as the sclerite encloses the hood as well as the other part of the penis-tip, it seems probable that no part of it corresponds to the ring, but that this sclerite is entirely wanting in the present specimen. The penis-tip is divided into a dorsal and a ventral portion. The ventral part is a rounded lobe, thickly beset with hairs; the dorsal part forms a membranous base from which arise three pairs of appendages. Beginning

at the most proximal, these appendages are a pair of horns, twisted at the base; a pair of membranous lobes, thickly beset with hairs irregularly arranged; and lastly two slender horns (Fig. 6).

We appear to have in *Diplax vicina* a more primitive condition than in *Diplax rubicundula,* in that the base which bears the appendages at the penis-tip is elongated so that they arise in succession instead of forming a clump. The inner horns are very probably the result of the division of the fork of *D. rubicundula,* and the other parts appear to be homologous respectively with the hood, the twists and the banners of that insect.

In *Celithemis elisa,* the mesal part only of the caudal edge of the ventral sclerite is emarginate. The hamules are inconspicuous, being but little larger than the genital lobes; their basal part is membranous or but slightly chitinized and the lobes are long, stout, and of nearly equal length. The framework which bears the hamules is strongly chitinized; its lateral projections (Fig. 8, *m*) are long and stout; the part of the median triangle (*n*) cephalad of the framework is short, but the triangle extends caudad farther than in other forms.

In the genital bladder the two latero-cephalic triangles of the ventral face are replaced by a single sclerite, somewhat cleft mesally, which apparently corresponds to the two united. The bladder is attached only by a small proximal neck and the dorsal aspect bears a tapering triangular sclerite (Fig. 9, *s*), each basal angle of which is attached to one side of the sclerite (*w*).

As to the distal segment of the penis, the shield is a broad sclerite, bearing lateral hornlike projections which point ventrad. The ring is of smaller diameter, but is very long, and has in general much the shape of a boddice; its edges meet on the dorsal line, but, so far as I can make out, do not unite. These edges are prolonged distad into two rodlike pieces (2). The fork is represented by a thick yellow sclerite, somewhat bifid, which lies close beneath but is quite free from these pieces (5). Laterad and proximad of the fork are a pair of tiny membranous lobes apparently corresponding to the banners (4). The hood is a large membranous lobe, thickly beset with hairs (3).

In this species, the twists of *D. rubicundula* appear to be entirely wanting. It is just possible, of course, that they may have moved dorsad and fused with the ring forming the rodlike projections of the sclerite. I have, however, no evidence tending to show that this has taken place, and in the absence of such evidence it cannot be assumed. We must suppose, therefore, that the twists are absent and that these rodlike projections are new developments. The advantage of having the genital bladder provided with three sclerites seems evident, so that *C. elisa* is probably primitive, since retrogression is hardly likely to be accomplished by fusion. There seems some slight reason for believing also that the condition of the fork found in this species is the original one, and that the two horns found in *D. vicina* have arisen by the division of

what was originally a single sclerite, while the condition in *D. rubicundula* represents an intermediate stage.

The relation of the parts in these three species are, in the main, tolerably clear. But when we turn to Libellula the problem is much more complicated. Not only have I not been able to homologize the parts found in Diplax and those of this genus, but I have also found it impossible to determine the relations of the parts found in different species of Libellula. I can therefore give little more than a bare description.

We may begin with *Libellula exusta*. The general arrangement is much as in Diplax. The genital lobes are short and stout. The ventral sclerite is wide, short, and only slightly emarginate caudally (Fig. 11, *e*). The lateral parts of the free edges are somewhat undulate. The hamules are stout and are membranous proximally, and the tip of the spur is very strongly incurved. The framework is wide and strong. The lateral rods are connected for their entire length to that part of the framework caudad of them by feebly chitinized triangles (*x*). The triangle (*n*) borne by the middle part of the framework is very long; its apex lies under the free edge of the ventral sclerite.

The cephalic part of the bladder is chitinized in a single sclerite with a mesal cleft. The last segment of the penis is made up mainly of a single large sclerite (Fig. 12, p_3), much longer on the dorsal than on the ventral surface. Its edges approach but do not quite meet on the ventrimeson. There is a curious dorsal hump on the distal part of the sclerite and the distal edge bears ventrally a pair of small, spine-like projections. If this sclerite is the result of the fusion of the shield and the ring there is no indication of the fact. As to the distal part of the segment, it projects only slightly beyond this sclerite; it consists of two pairs of appendages rising from a full membranous base. The median and dorsal pair are sigmoid rods curved towards the dorsal surface at their distal ends (*u*). The second pair are membranous at base but strongly chitinized distally (*v*).

I would suggest the following as the possible homologies of some of these parts: the large sclerite corresponds to the shield; the ring is wanting; the hood is represented in a much less differentiated state than in Diplax, by the full membranous portion of the penis-tip. As to the homologies of the other parts I am entirely uncertain.

In *Libellula pulchella*, the blunt division of the hamule lies almost laterad instead of caudad of the spur; it is moreover reduced nearly to a knob. The spur is long and strong and its point turns laterad.

The dorsal aspect of the genital bladder, though normally united for a considerable portion of its extent with the abdomen, separates readily therefrom after maceration in caustic potash. In the penis, the first segment is extremely long and bears a dorsal terminal tubercle; the second segment is very small and triangular; the third bears distally a large dorsal upgrowth. The edges of this sclerite do not quite meet ventrally, and between the angles projects a small membranous lobe which per-

haps corresponds to the hood of Diplax. Attached to the base of this structure on either side is a tiny, membranous, finger-like lobe. The tip of the penis is formed by a great mass of membrane which projects from the distal end of the third sclerite described above. This membrane is covered with scattered chitinized papillæ and is chitinized in such a way as to form a pair of irregularly shaped sclerites, somewhat like a moose's antlers, narrow at the base, broadening distally and uniting dorsally and ventrally so as to form a ring which divides the membrane into a proximal and a distal division. This arrangement will be made clear by a glance at the diagram (Fig. 14). At the base of these sclerites on either side is a small piece visible after the removal of the shield; these pieces appear to be rudiments of structures much more developed in *L. quadrupla.*

In *L. quadrupla,* the general appearance is much the same as in the species last described; there are, however, one or two interesting differences in the penis-tip. The hood is bi-lobed and so far as I could discover, there are no such lobes laterad of it as in *L. pulchella.* The membranous tip of the penis is not chitinized in any part, but the chitinous papillæ with which it is beset are much more closely placed in a region which corresponds with that part which in *L. pulchella* is chitinized. It seems possible that this massing of papillæ is, so to speak, an attempted adaptation to certain unkown conditions and that the chitinization is a more satisfactory adaptation to the same conditions. The dorsi-mesal portion of the membrane is largely free from papillæ and is extended into a long, finger-like, membranous tip.

Plathemis trimaculata is in several respects a most interesting species. The first abdominal segment bears on its ventral aspect a pair of chitinous lobes; these structures have a position on the first segment exactly corresponding to that which the hamules occupy on the second, and their form is not unlike that of the undivided hamules found in many kinds of Libellulinæ. They are, however, continuous with the abdominal wall instead of being jointed to it as are the hamules.

In the second segment, the sternum is short; it bears on its free edge a small median lobe which is indented on the mesal line so as to form two scallops (Fig. 16). The hamules show only very slight differentiation into lobes. The cephalic lobe, which corresponds to the spur of the ordinary hamule, is shaped somewhat like a man's boot, the toe of the boot being turned towards the caudal lobe. The toe alone is free, but from the point of division between the two lobes a membranous band extends towards the base of the hamule; if this membrane were unfolded the condition found in the other Libellulinæ would be produced. The caudal lobe is deeply grooved at its tip so that it appears almost bilobed. I am unable to describe the penis.

This species seems to me to give us some reason to believe that the hamules are the survivors of the series of abdominal appendages present in the ancestor of the insects. And in this connection, I would suggest

the possibility that the penis is to be regarded as the fused and greatly modified abdominal appendages of the third abdominal segment. The hamules of Plathemis also afford us a suggestion of the way in which the branched may have arisen from the simple condition.

Conclusion: While my work has been mainly description, there are a few general suggestions which may be thrown together here. 1. There seems some reason for believing that the hamules are homologues of abdominal appendages. 2. Various stages are observed between the ordinary bifid condition of the hamules and the uniramous condition of other subfamilies. As we have no reason to believe that the abdominal appendages were originally biramous, we must suppose the condition in Libellulinæ a secondary one. 3. It has been impossible to homologize the appendages of the penis-tip, though there seems some reason to think that wider study might enable one to do it. 4. The resemblance between these appendages in *Diplax vicina* and *rubicundula* is very close; *Celithemis elisa* is quite different in some respects. This species was formerly placed in the genus Diplax; the marked difference and the general similarity of the penis-tip is what we should expect in two genera so closely related as to have been formerly classed as one and leads us to believe that the study of this organ may prove to be of systematic importance. In conclusion, I wish to acknowledge the valuable aid given me by Prof. M. A. Willcox in the preparation of this paper, both in general suggestion and revision. I have found no literature which was of value save Rathke's paper, "De Libellarum Partibus Genitalibus."

Description of Diagrams, Plates XIV and XV.*

Diplax rubicundula.

Fig. 1. One-half of tergum.
Fig. 2. Second segment—ventral view.
Fig. 3. Framework, triangle, and hamules.

Diplax vicina.

Fig. 4. Second segment—ventral view.
Fig. 5. Framework, triangle, hamules, and sternum.
Fig. 6. Genital bladder and side-view of penis.

Celithemis elisa.

Fig. 7. Second segment—ventral view.
Fig. 8. Framework, triangle, hamules, and sternum.
Fig 9. Genital bladder and penis—dorsal view.

Libellula exusta.

Fig. 10. Second segment—ventral view.
Fig. 11. Framework, triangle, hamules, and sternum.
Fig. 12. Genital bladder and side-view of penis.

* The scale by which drawings were made differs, but as size in mm. is given, there need be no misunderstanding.

Libellula pulchella.

Fig. 13. Framework, triangle, hamules, and sternum.
Fig. 14. Genital bladder and side view of penis.

Libellula quadrupla.

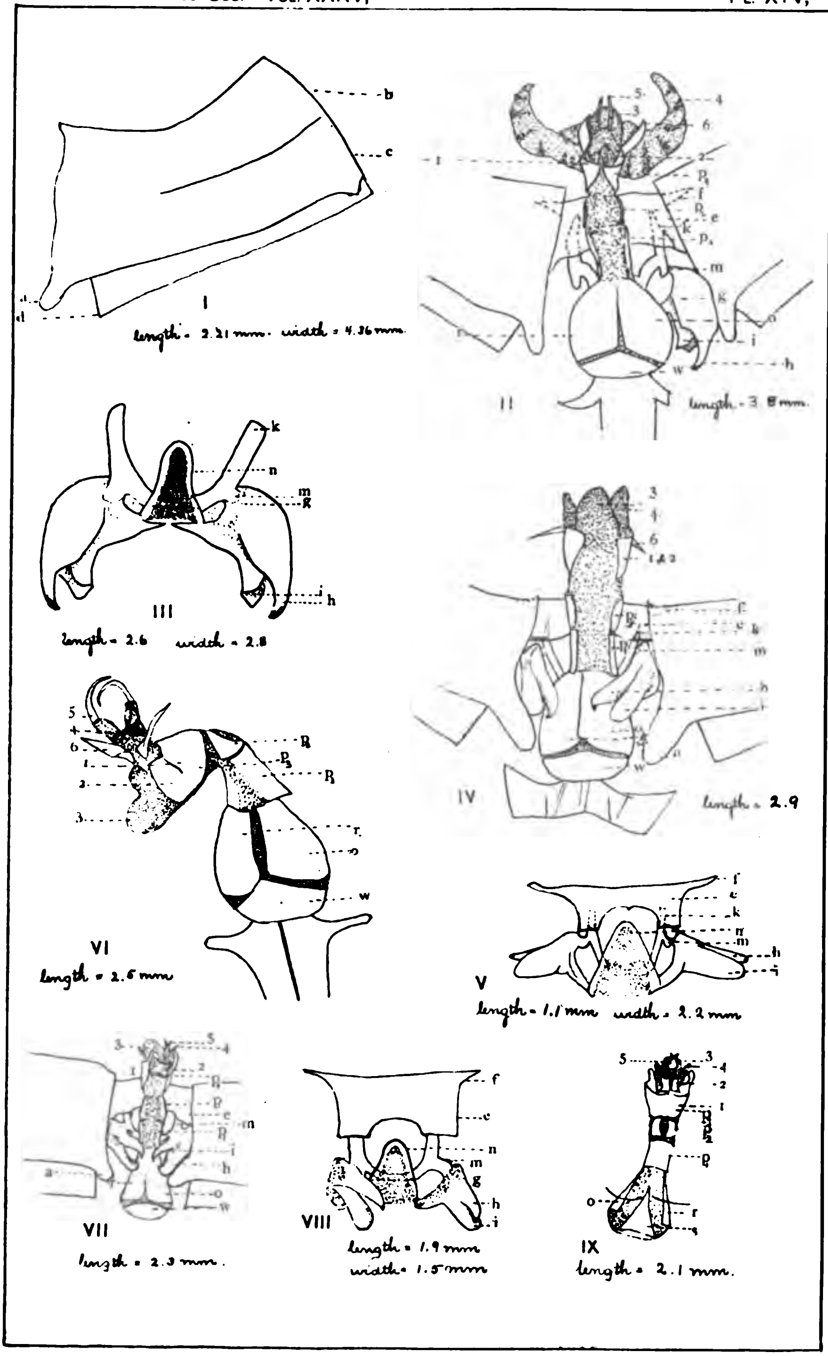
Fig. 15. Genital bladder and penis—side view.

Plathemis trimaculata.

Fig. 16. Framework, triangle, hamules, and sternum
Fig. 17. Genital bladder and penis—ventral view
Fig. 18. Penis—dorsal view.

In the above diagrams, the letters stand for organs as follows:

a. Genital lobe. *b*. First segment of tergum. *c*. Second segment of tergum. *d*. Third segment of tergum. *e*. Sternum. *f*. Triangular appendage of sternum. *g*. Hamule. *h*. Spur of hamule. *i*. Truncate lobe of hamule. *k*. Framework. *m*. Lateral rod of framework. *n*. Triangle. *o*. Left cephalic triangle of genital bladder. p_1, p_2, p_3. Segments of penis. *r*. Right cephalic triangle of genital bladder. *s*. Dorsal triangle in genital bladder of *Celithemis elisa*. *t* and *y*. appendages of penis of *Plathemis trimaculata*. *u* and *v*. Appendages of penis of *Libellula exusta*. *w*. Caudal triangle of genital bladder. *x*. Membranous appendage of framework in *Libellula exusta*. 1. Shield of third segment of penis. 2. Ring. 3. Hood. 4. Banner. 5. Fork. 6. Twist.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III
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IV
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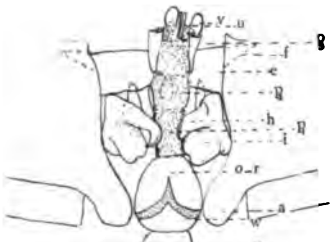
VI
length = 2.6 mm
V
length = 1.1 mm width = 2.2 mm
VII
length = 2.3 mm.
VIII
length = 1.9 mm
width = 1.5 mm
IX
length = 2.1 mm.



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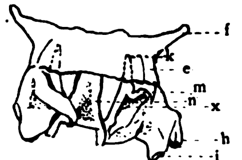

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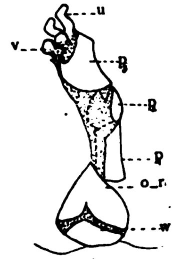

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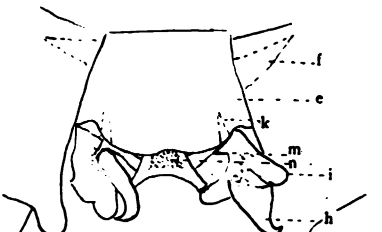

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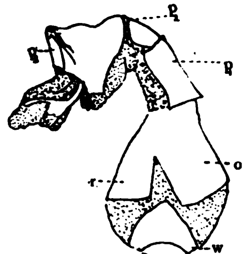

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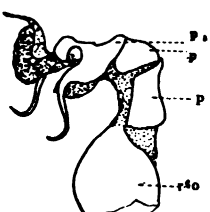


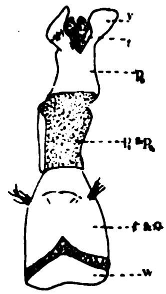
XV

length = 3.3 mm

XVI

length = 1.9 mm.
width = 3.8 mm.

XVIII



XVII

*Marine Fossils from the Coal Measures of Arkansas.**

By James Perrin Smith.

(Read before the American Philosophical Society, October 2, 1896.)

CONTENTS. PAGE.

*An abstract of this paper was published in *Journal of Geology*, Vol. II, No. 2, pp. 187-204.

Preface.

The Coal Measures cover an area of 14,700 square miles in the State of Arkansas. The greater part of this area lies in the geosyncline of the Arkansas Valley. The total thickness of the sediments in this geosyncline is enormous—24,000 feet. These conditions, taken in connection with the occurrence in these sediments of both land plants (coal beds) and of marine fossils seem to show that the beds were deposited upon a subsiding (for the most part) floor, and that the land stood near the sea level, below which it occasionally sank.

The marine fossils from the Coal Measures area, so far as they were collected by the Geological Survey of Arkansas, are listed and described in the following paper kindly prepared at my request by Dr. J. P. Smith, of Stanford University. It is volunteer work done originally for the State Survey, and was to have been published in a volume upon the paleontology of Arkansas. Upon the abolition of the Survey by the Legislature in 1893 several volumes of reports were left unpublished, and among them one on the paleontology of the State.

John C. Branner,
Late State Geologist of Arkansas.

Stanford University, California, July 10, 1896.

Introduction.

Marine fossils afford the best means of correlating strata of different regions, but in the Coal Measures they are usually rare, and therefore of especial interest and value when found.

Of all the Paleozoic systems the Carboniferous is most subject to facies variations, which make it difficult and often impossible to recognize with certainty the minor subdivisions at any great distance from the place where they were first established. This is true even of the Mississippian formation, whose limestones were deposited under comparatively uniform conditions, so that one would expect the faunal relations to be the same over the whole area where the Mississippian facies prevails. But the American Coal Measures were formed under conditions not favorable to uniformity either of rock character or of life, hence the correlation of these strata becomes more difficult. And in these geologists have been more prone to rely on lithologic characters and unaided stratigraphy. Such correlations have only a local value, and cannot be extended over any wide scope of territory. For this reason no divisions of the Coal Measures into zones has every been carried out, nor can it be done, in the present state of our knowledge.

Previous to the collections made by the Geological Survey of Arkansas, marine fossils were known from but a single locality in the Coal Measures of Arkansas. Dr. David Dale Owen, in his *Geological Reconnoissance of Arkansas*, Vol. i, p. 68, says: "Three miles north-

west of Searcy, at a 'bald point,' in the vicinity of the widow Gilbert's farm, sixty feet of shaly strata are exposed, dark or nearly black, in its lower part, and reddish yellow and ferruginous towards the top. The shale includes numerous segregations of carbonate of iron and carbonate of lime; the latter containing several fossil marine shells, amongst which the *Nautilus ferratus* was discovered, a species which occurs in the ferruginous shales of Nolin, in Edmonson county, Ky." The locality mentioned is now known to be in the Lower Coal Measures, and is situated not three but thirteen miles northwest of Searcy.

F. B. Meek, in the *Final Report of the U. S. Geological Survey of Nebraska,** mentions *Hydreinocrinus* (*Zeacrinus*) *mucrospinosus* McChesney, from the Coal Measures of Arkansas, but he does not cite any authority for the statement, nor does he say he has seen this fossil from Arkansas, or give any locality. In all the other literature where this species is mentioned, nothing is said about Arkansas. It is, therefore, concluded that this species was never found in the State. It was, however, found by the Geological Survey, in strata of the Upper Coal Measures, on Poteau mountain, Indian Territory, two miles west of the line of Scott county, Arkansas.

Featherstonhaugh† mentioned a "new species of pentremite in the old red sandstone of Maumelle." The strata of Maumelle mountain, Pulaski county, are of Lower Coal Measure age, and it is not likely that a pentremite was ever found there, since the systematic searches of the Survey failed to find any fossils in this region.

Localities Discovered by the Survey.

Marine Coal Measure fossils were found by the Survey at twenty-one different places, besides that mentioned by Owen. These extend from Independence county westward to Indian Territory, giving a total of forty-eight genera and ninety species, forty-eight in the Lower Coal Measures, and fifty-two in the Upper, with ten species common to both. It is not thought that this small number of species represents the entire fauna, or that only ten species are common to the two divisions, for the collections were much too scattered and meagre to exhaust the possibilities. But the fauna is a poor one, such as one would expect to wander in from deeper waters whenever a slight subsidence made the shallow waters a little more habitable. The faunas could not become well established, because the conditions soon reverted to their old state, and the inhabitants of the seas were forced to migrate or be exterminated.

There is, therefore, in this region no gradual transition from the fauna of the Lower Carboniferous limestone, and the fossils of the Lower Coal Measures are just as different from those of the Lower Carboniferous as are those of the Upper Coal Measures.

It is not attempted to carry the division further than into Upper and

* Op. cit., p. 149.

† *Geolog. Rep. Elevated Country between the Missouri and Red Rivers*, p. 61.

Lower Coal Measures, and even this division is often uncertain, for in most cases the relations of the fossiliferous beds to each other could not be determined with any degree of certainty. Also in most of this region the stratigraphy is difficult; the rocks vary so little, and are so folded and faulted that by stratigraphy alone it was often impossible to locate a bed within several hundred feet.

In addition to this, the number of the species is usually too small, and their character too indecisive to enable one to say with certainty to which division the strata belonged. Therefore, in enumerating the localities there are given only the character of the rocks, the fossils found in them, and the place in the section where these strata are thought to belong.

Lower Coal Measures.

Of these localities there were seventeen discovered, and they will be given in order from east to west.

No. 1. Independence county, 11 N., 5 W., section 9, centre of the section. Soft brownish sandstone with *Euomphalus* (*Straparollus*) sp.; near the middle of the Lower Coal Measures. Collector, J. C. Branner.

No. 2. White county, 8 N., 7 W., section 26, Bee Rock on Little Red river. Massive yellowish sandstone, over one hundred feet exposed, nearly horizontal; at the top with marine fossils, at the bottom with plants. Near the base of the Lower Coal Measures. Collector, J. P. Smith.

Crinoid stems.
Productus semireticulatus Martin.
Spirifer rockymontanus Marcou.
Aviculopecten carboniferus Stevens.
Bellerophon sp.
Plant remains, undetermined.

No. 3. White county, 8 N., 7 W., section 33, east half of southeast quarter, south of Norton's field, on the road from Searcy to Griffin Springs. Hard yellowish and in places ferruginous sandstone, with a dip of about 30° south. Horizon same as the last locality. Collector, J. P. Smith.

Fenestella sp.
Orthis conf. *resupinoides* Cox.
Productus semireticulatus Martin.
Rhynchonella sp.
Spirifer rockymontanus Marcou.
Schizodus conf. *amplus* Meek and Worthen.
Bellerophon sp.

No. 4. White county, 9 N., 4 W., section 6. Soft pinkish sandstone. Near middle of Lower Coal Measure. Collector, J. C. Branner.

Phillipsia (*Griffithides*) *scitula* Meek and Worthen.
Euomphalus (*Straparollus*) *subquadratus* Meek and Worthen.
Athyris subtilita Hall.
Prestwichia sp. or a new genus closely allied to *Prestwichia*.

No. 5. White county, 9 N., 5 W., section 1. Soft reddish sandstone, similar to that of locality No. 4, containing also *Phillipsia* (*Griffithides*) *scitula* Meek and Worthen. Collector, J. C. Branner.

No. 6. Lonoke county, 4 N., 10 W., section 12, southeast quarter of northwest quarter. Gray quartzite conglomerate seen in a well by the roadside to dip 45° south. Towards base of Lower Coal Measure. Collector, J. P. Smith.

Crinoid stems, undetermined.

No. 7. Conway county, 6 N., 16 W., section 29, southwest quarter of southwest quarter, on east bank of Arkansas river, about one mile below the Old Lewisburg ferry. A brown ferruginous shale near the top of the Lower Coal Measures and probably a few hundred feet above the shales of locality No. 8. Collector, J. F. Newsom.

Productus punctatus Martin.
Derbyia crassa Meek and Hayden.
Orthis pecosii Marcou.
Spirifer cameratus Morton.
Spiriferina cristata Schlotheim.
Athyris subtilita Hall.
Terebratula hastata Sowerby.
Aviculopecten occidentalis Shumard.

No. 8. Conway county. 5 N., 16 W., section 17, two hundred yards west of the centre of northwest quarter, west of the Arkansas river, and four miles south of Morrillton. The horizon is near the top of the Lower Coal Measures. Reddish ferruginous shale. Collector, J. F. Newsom.

Phillipsia (*Griffithides*) *ornata* Vogdes.
Zaphrentis sp.
Nucula parva McChesney.
Nucula ventricosa Hall.
Macrodon carbonarius Cox.
Conocardium aliforme Sowerby.
Aviculopecten occidentalis Shumard.
Aviculopecten carboniferus Stevens.
Pleurophorus oblongus Cox.
Bellerophon carbonarius Cox.
Bellerophon crassus Meek and Worthen.
Pleurotomaria sp.
Macrocheilus (*Soleniscus*) conf. *primigenius* Conrad.
Macrocheilus conf. *fusiformis* Hall.
Goniatites (*Paralegoceras*) *iowensis* Meek and Worthen.

Nautilus (*Ephippioceras*) *ferratus* Cox.
Nautilus (*Endolobus*) *missouriensis* Swallow.

No. 9. Conway county, 7 N., 16 W., section 8, northeast quarter of northeast quarter, about two hundred yards east of the centre; one hundred yards northwest of the iron bridge. Ferruginous, porous sandstone, full of poorly preserved casts of fossils, that could not be specifically identified. This horizon lies about one thousand feet below that of locality No. 7, near Old Lewisburg, and is probably the same as that of locality No. 10, Cook's quarry, near Hattieville. Collector, J. F. Newsom.

Zaphrentis (?).
Crinoid stems.
Spirifer sp.
Euomphalus sp.

No 10. Conway county, 8 N., 17 W., section 33, northeast quarter of northeast quarter, Cook's quarry, near Hattieville. Hard yellowish sandstone. Upper part of Lower Coal Measures. Collector, J. F. Newsom.

Orthoceras sp.
Astartella newberryi Meek.
Aviculopecten occidentalis Shumard.
Edmondia unioniformis Phillips.
Schizodus wheeleri Swallow.
Schizodus cuneatus Meek.
Bellerophon carbonarius Cox.
Pleurotomaria harii S. A. Miller.
Pleurotomaria sp.
Euomphalus sp.
Orthoceras sp.
Orthis resupinoides Cox.
Orthis sp.
Terebratula hastata Sowerby.

No. 11. Pope county, 10 N., 20 W., section 8, southeast quarter of northwest quarter. Ferruginous shale like that near Morrillton. Collector, H. E. Williams.

Crinoid stems.
Pleurotomaria sp.
Goniatites (*Gastrioceras*) *excelsus* Meek.

No. 12. Johnson county, 11 N., 24 W., section 26, southwest quarter of southwest quarter. Brownish ferruginous sandstone. Collector, A. G. Taff.

Phillipsia sp.

No. 13. Franklin county, 11 N., 27 W., section 4, southeast quarter of

northeast quarter. Weathered ferruginous sandstone. Collector, A. G. Taff.

Crinoid stems.
Spirifer sp.

No. 14. Franklin county, 10 N., 26 W., section 2, southeast quarter of southeast quarter. Ferruginous sandstone Collector, A. G. Taff.

Bellerophon carbonarius Cox.

No. 15. Franklin county, 11 N., 28 W., section 27, northeast quarter of southeast quarter Ferruginous sandstone. Collector, A. G. Taff.

Pleurotomaria sp.

No. 16. Crawford county, 12 N., 30 W., section 17, northeast quarter of southeast quarter. Brownish sandstone, very like that of Bee Rock, White county. Collector, E. C. Buchanan.

Spirifer rockymontanus Marcou.

No. 17. Carroll county, 17 N., 19 W., northeast corner of section 18; Pilot mountain, three and a half miles southwest of Valley Springs. Millstone grit, about sixty feet above a brownish limestone supposed to represent the Chester horizon. Collector, Stuart Weller.

Gastrioceras branneri n. sp. J. P. Smith.
Pronorites cyclolobus Phillips, var. *arkansiensis* nov. var. J. P. Smith.

Upper Coal Measures.

In the Upper Coal Measures, three localities were discovered by the Survey, giving fifty-two species, of which thirty-two were found on Poteau mountain, Indian Territory.

No. 1. Scott county, 1 N., 28 W., section 4, southeast quarter of southeast quarter. Yellow ferruginous shale, with fossils in hard nodules. This horizon is probably equivalent to the Canyon division of Texas, lower part of Upper Coal Measures, since many similar fossils were found in that horizon by the Geological Survey of Texas. Collector, C. E. Siebenthal.

Cyathocrinus (?).
Conularia conf. *crustula* White.
Naticopsis sp.
Nuculana aff. *bellistriata* Stevens.
Pleurophorus sp.
Goniatites (*Gastrioceras*) sp. indet.
Goniatites (*Gastrioceras*) *globulosus* Meek and Worthen.
Goniatites (*Gastrioceras*) *marianus* Verneul.
Goniatites (*Pronorites*) sp.
Orthoceras conf. *rushense* McChesney.

While the stratigraphy seems to place these beds in the Lower Coal Measures, the fossils are decidedly Upper Coal Measure forms, and are characteristic of that horizon in Texas, Kansas, etc.

No. 2. Crawford county, 10 N., 30 W., section 10, southeast quarter of northwest quarter. Soft ferruginous shale. Collector, C. E. Siebenthal.

Zaphrentis sp.
Rhynchonella sp.
Macrodon sp.
Dentalium conf. *meekianum* Geinitz.
Polyphemopsis inornatus Meek and Worthen.
Pleurotomaria modesta Keyes.
Nautilus sp.

No. 3. Sebastian county, 8 N., 32 W., section 12. Ferruginous shale near Mr. Wilson's house. High up in Upper Coal Measures. Collector, Arthur Winslow.

Crinoid stems.
Fistulipora nodulifera Meek.
Athyris subtilita Hall.
Productus splendens Norwood and Pratten.
Retzia mormonii Marcou.
Spirifer cameratus Morton.
Spiriferina cristata Schlotheim.
Macrodon obsoletus Meek.
Nucula parva McChesney.
Bellerophon carbonarius Cox.
Bellerophon marcouanus Geinitz.
Naticopsis nana Meek and Worthen.
Pleurotomaria sp.

No. 4. Poteau mountain, Indian Territory, two miles west of the Scott county, Arkansas, line, on the east fork of Sugar creek, 150 feet below the southern crest of the mountain. The fossiliferous bed is a soft gray shale about four inches thick. About 1000 feet of shales lie above this, but no fossils were found in them. The fossiliferous bed is several hundred feet above the highest bed of coal known in that region.

The following fossils were collected here by C. E. Siebenthal:

Lophophyllum proliferum McChesney.
Erisocrinus (*Ceriocrinus*) *inflexus* Geinitz.
Hydreinocrinus mucrospinosus McChesney.
Poteriocrinus (?).
Orthis pecosii Marcou.
Derbyia crassa Meek and Hayden.
Productus cora d'Orbigny.
P. splendens Norwood and Pratten
Rhynchonella uta Marcou.
Terebratula hastata Sowerby.
Retzia radialis Phillips.
Athyris subtilita Hall.
Spirifer cameratus Morton.

Spiriferina cristata Schlotheim.
Fistulipora nodulifera Meek.
Rhombopora lepidendroides Meek.
Septopora biserialis Swallow.
Aviculopecten coxanus Meek and Worthen.
A. germanus Miller and Faber.
Lima retifera Shumard.
Macrodon carbonarius Cox.
M. tenuistriatus Meek and Worthen.
M. obsoletus Meek.
Astartella vera Hall.
A. newberryi Meek.
Edmondia nebrascensis Geinitz.
Pleurotomaria tenuicincta Meek and Worthen.
P. conf. *speciosa* Geinitz.
Orthoceras cribrosum Geinitz.
Phillipsia cliftonensis Shumard.
Calamites sp.

A fauna of probably the same age has been described from the upper part of the Wyoming Valley limestones of the Upper Productive Coal Measures of Pennsylvania.*

Fayetteville Shale.

In Scott county, 2 N., 29 W., section 36, near the centre, C. E. Siebenthal and J. F. Newsom discovered a bed of brown thinly laminated shale, with some sandy layers, containing pyritiferous nodules in which *Goniatites* (*Glyphioceras*) conf. *sphæricus* Martin was found in a good state of preservation. In the shale itself were found many poorly preserved specimens of the *Goniatites* conf. *sphæricus*, and countless specimens of *Posidonomya* (*Lunulicardium*) conf. *fragosum* Meek, also many specimens of *Orthoceras* sp.

These were at first thought to belong to the Coal Measures, but a very similar bed of shale, with the same fossils in the identical state of preservation, were found at Moorefield, Independence county, in the Fayetteville shale, which probably corresponds to the Warsaw group of the Lower Carboniferous.

Comparison with the Permo-Carboniferous of Kansas and Nebraska.

It will readily be seen that the fauna of the Upper Coal Measures of Arkansas bears a strong resemblance to that of the youngest Paleozoic beds of Nebraska, described as Permian by Prof. Geinitz in his monograph, "Carbonformation and Dyas in Nebraska."

F. B. Meek † redescribes this fauna, and comes to the conclusion that

* *Penna. Geol. Survey Ann. Rep.*, 1885, pp. 437–458, C. A. Ashburner and A. Heilprin, "Report on the Wyoming Valley Limestone Beds."

† *Final Report U. S. Geol. Survey Nebraska*, p. 128, *et seq.*

the rocks in question are not to be referred to the Permian, because he can find no paléontologic or stratigraphic break in the series. He finds sixteen genera characteristic of the Carboniferous and seven genera not thought to antedate the Permian in Europe, but associated with genera not thought to occur later than the Carboniferous. Meek* says that Fusulina, which occurs in great numbers in the Upper Coal Measures of Nebraska, is considered in Europe to be mainly a Lower Carboniferous genus. In this, however, he was mistaken; his opinion dates from the time when geologists were inclined to place all Carboniferous limestone in the Lower Carboniferous. But it is now known that Carboniferous limestone occurs in the Upper Carboniferous about as often as in the Lower, and that the Fusulina limestones of Sicily and Russia grade over into beds of undoubted Permian age.

This is also true of corresponding beds in the upper part of the Carboniferous of Texas, since the line between Permian and Coal Measures is purely arbitrary.

Although undoubtedly believing in continuity of life and formations, Meek seems to have based his reasoning somewhat upon the old idea of catastrophies, since he thought that the absence of a paleontologic or stratigraphic break was a sufficient reason for calling the beds in question Upper Coal Measures rather than Permian. A large majority of the genera and species are characteristic of the Carboniferous, and this Meek thinks sufficient to offset the fact that several genera previously considered typical of Permian are present. But some of these doubtful strata have at last been acknowledged to be Permian† by Williams and Tschernyschew, and Prof. Hyatt has described in the *Fourth Annual Report of the Geological Survey of Texas* several cephalopods that are common to the Permian of Texas and of Kansas.

In the Upper Coal Measures of Arkansas, out of fifty-two species, there are twenty-five in common with the doubtful strata of Nebraska, and eleven other species are common to the Nebraskan Permo-Carboniferous and the Lower Coal Measures of Arkansas, but have not yet been found in the Upper Coal Measures of the latter state. But of the genera mentioned by Meek as being not considered to antedate the Permian of Europe only two are found in the Arkansas strata, namely, *Synocladia*‡ and *Lima*.

There is not sufficient reason for classing the Poteau mountain beds with the Permian, but their fauna, as well as stratigraphic position, place them very high in the Coal Measures, since they are like the fauna and position of the Mississippi Valley Upper Coal Measures.

These beds derive an additional interest from the fact that on Poteau

* P. 133, *op. cit.*

† *Trans. Kansas Acad. Sci.*, Vol. xiii, p. 38.

‡ Waagen has shown in *Pal. Indica*, *Salt Range Fossils* I, *Productus Limestone Fossils*, p. 802, that *Synocladia* is not found in America, the species described by Swallow as *Synocladia biserialis* being a *Septopora*. There is also some doubt as to whether *Lima retifera* is a true *Lima*.

mountain, 1000 feet of shale, in which no fossils were sought for, lie above the thin layer from which the entire collection was taken; thus the chances of finding true Permian beds in that region are very good.

Relations to the Texas Upper Carboniferous.

The most philosophical presentation of the Permian problem in America has been given by Dr. C. A. White.* He finds the fauna of the upper Paleozoic beds of northern Texas, discovered by Prof. W. F. Cummins, to be analogous to that of the Fusulina Limestone of Sicily, the Artinsk stage of Russia, and the upper Productus Limestone of the Salt Range in India. These strata all show that peculiar commingling of ordinary Coal Measure fossils with ammonite genera, such as *Popanoceras, Medlicottia* and *Waagenoceras,* which seems to be characteristic of open sea facies of the Permian.

None of the characteristic ammonite genera were found in the Arkansas region, but nearly every fossil found in these Coal Measures was also found in Texas. And in the Texas Permian nearly all the species excepting the ammonites were found in the underlying Upper Coal Measures. This makes the analogy between the Upper Coal Measures of the two regions very strong.

Nearly all these fossils are also found in Illinois, Iowa, etc., in beds that have never been thought to be other than Coal Measures.

We are, therefore, safe in concluding that while some of the beds in western Arkansas are very high up in the Coal Measures, none that belong above them are as yet certainly known, and the Poteau mountain syncline, across the line in Indian Territory, is the only place where there is any likelihood of finding Permian deposits. These beds may turn out to be the equivalents of the Wichita division of the Texas Permian, which, as Prof. W. F. Cummins has told the writer, contains the exact fauna of his Albany division. The Albany beds were formerly thought to be Coal Measures; and Prof. Cummins' work in determining them by paleontology as well as stratigraphy to be the equivalents of the Wichita division will be of great help in the study of the doubtful so-called uppermost Coal Measure strata all over the Mississippi Valley. Many of these strata are very probably the homotaxial equivalents of the Albany division, and of the Artinsk stage of the Ural mountain region.

Comparison with Foreign Upper Carboniferous.

The Lo-ping Fauna of China.

The descriptions of the fauna of this Lo-ping district of China by Prof. E. Kayser† throw great light on the relations of American Carboniferous faunas to those of Asia. Near Lo-ping, in eastern China, are

* Bulletin 77, *U. S. Geol. Survey.*

† Richtofen's *China,* Vol. iv.

found in beds overlying the coal beds numerous marine fossils of Upper Coal Measure age. Kayser has described fifty-five species, ten not specifically identified, fifteen cosmopolitan species, and eleven forms that are typically American, and belong chiefly to the Upper Coal Measures.

Macrocheilus anguliferus.
Schizodus wheeleri.
Macrodon carbonarius.
Aviculopecten maccoyi.
Retzia compressa.
Orthis pecosii.
Productus mexicanus.
Rhombopora lepidendroides.
Lophophyllum proliferum.
Lophophyllum proliferum var. *sauridens.*
Fusulina cylindrica var. *gracilis.*

Also the *Nautilus orientalis* Kayser is most closely related to *N. occidentalis* Swallow, and *Nautilus mingshanensis* Kayser resembles the same American species. *Myalina trapezoidalis* Kayser finds its nearest representative in *M. subquadrata* Shumard. The fifteen cosmopolitan species are also nearly all found in the American Upper Coal Measures, so that of the entire Lo-ping fauna nearly all the species are either found in America, or they have their nearest relatives there. The two regions belong to the same zoölogical province, the Pacific Carboniferous sea.

Many of these species that are very common in America and Asia are unknown or rare in Europe, which fact would tend to prove a connection with Asia by water, and the separation of the European and the American Upper Coal Measure deposits by a land barrier.

The Carboniferous plants collected by Baron von Richthofen numbered about forty species, and are nearly all identical with European Carboniferous plants. The natural inference is that in those times Asia was connected by land with Europe, while the sea opened out to the east.

Prof. J. S. Newberry * described a small collection of Carboniferous plants from China, and found nearly all of them to belong to well-known European species. This is in perfect agreement with the conclusions drawn above.

The Salt Range Beds of India

In the Salt Range, in northwest India, are found Upper Carboniferous deposits, some of which resemble those of Lo-ping, China, and the Lower Productus Limestone of India is probably of the same age as the beds of Lo-ping, and the western American Uppermost Coal Measures. These deposits and their fauna are described by Prof. W.

* *American Journal of Science*, Vol. cxxvi, 1883, p. 123 *et seq.*

Waagen, in the *Paleontologia Indica*, and in the volume on *Geological Results* he draws some very interesting parallels between the faunas of the Upper Carboniferous in different countries. Many of the American species that are found at Lo ping are also found in the Salt Range beds. This same type of Carboniferous is found on Sumatra, where it has been described by Ferd. Roemer,* and on Timor, where it was described by E. Beyrich.†

This is the furthest southward that the Indian or northern type of Upper Carboniferous is known, and indeed the deposits of Sumatra and Timor begin to show already a greater affinity for the Australian or southern deposits.

Waagen‡ divides the Carboniferous into two types—the northern, or Asiatic, and the southern, or Australo-African. The northern type is found in western Europe, Russia, the Himalayas, China, the Arctic regions, and North America. The southern type is developed in South Africa and Australia, and extends into Peninsular India and Afghanistan. Brazil probably belongs to this type, but is to a certain extent transitional.

The Itaitúba Fauna, Brazil.

A comparison of the Brazilian Upper Carboniferous fauna, as described by Prof. O. A. Derby,§ shows that of twenty-seven species of Brachiopoda twelve are identical with American forms, although most of these are cosmopolitan. The genus *Strophalosia* is common in these beds, and as Prof. Derby‖ says, the species shows affinity with the Permian. Many of the new species are closely related to European forms. Prof. W. Waagen,¶ says that the beds of Itaitúba are of the same age as the Middle Productus Limestone of India, that is of the Permo-Carboniferous transition beds. The Brazilian *Strophalosia* is closely related to Australian forms, indicating a closer connection with the Australian or southern Carboniferous region than with the Pacific province.

Classification and Age of the Arkansas Coal Measures.**

Provisional Classification.

The Coal Measures of Arkansas have been temporarily classified by the Survey, for the sake of convenience, as Upper or Productive, and Lower or Barren Coal Measures. The division is not based on any

* *Palæontographica*, Vol. xxvii, 1880.

† *Abhandlungen der Berliner Akademie der Wissenschaften*, 1865.

‡ *Salt Range Fossils, Geological Results*, p. 239.

§ *Bulletin Cornell University*, Vol. 1, No. 2, and *Journal Geol.*, Vol. ii, pp. 480–501.

‖ *loc. cit.*, p. 60.

¶ *Salt Range Fossils, Geological Results*, p. 207.

** The writer is greatly indebted to Messrs. E. T. Dumble and W. F. Cummins of the Geological Survey of Texas, for their kindness and courtesy to him in the Texas Museum, also for valuable aid in the correlation of the Coal Measures of Arkansas and Texas.

paleontologic or stratigraphic break, but merely on the occurrence or non-occurrence of coal.

The divisions that are recognized in Pennsylvania could not be recognized in Arkansas, but the strata of the two sections are correlated as far as possible, with the scanty data now at hand.

The Lower Coal Measures.

Of the age of the Lower Coal Measures we have only stratigraphic evidence, their position above the limestones of the Lower Carboniferous and below the coal-bearing beds of the Upper Coal Measures being unmistakable. But their known fauna and flora have been too limited and indecisive to enable us to correlate the stages with those of other Carboniferous areas, since collections have been made in but few places, and these chiefly in sandstones, where the preservation of fossils is usually unsatisfactory, and the determination uncertain.

But the Lower Coal Measures correspond in a general way to the Strawn and the lower part of the Canyon division of Texas, to the Pottsville Conglomerate series, the Lower Productive Coal Measures, and part of the Lower Barren Coal Measures of Pennsylvania. The series corresponds in the main to the Middle Carboniferous limestone of eastern Russia.

The Upper Coal Measures.

The Arkansas Upper Coal Measures correspond to the upper part of the Canyon and the whole of the Cisco division of Texas,* and below the transitional Permo-Carboniferous or Artinsk stage, to which latter age the lower part of the Wichita and Albany divisions of Texas belong. The Lower Permo-Carboniferous beds of Kansas and Nebraska are also probably to be correlated with the Artinsk† stage, although Waagen‡ classes the entire series with the ammonite-bearing beds of northern Texas, described by Dr. C. A. White, in Bulletin 77 of the U. S. Geological Survey. Most of the latter Texas beds belong rather above the Artinsk stage, and in the true Permian, and are probably of the same age as the *Middle* and *Upper Productus Limestone* of the Salt Range.

Waagen, in *Salt Range Fossils, Geological Results*, p. 238, gives a comparative table, showing the relationship of the upper Paleozoic strata all over the world. While the position assigned some of the American deposits does not agree with that accepted by most American geologists, still the table is very useful for comparison, and it has been freely used in compiling the comparative table accompanying this paper.

* The writer, in *Journal Geology*, Vol. ii, p. 194, following Karpinsky, placed the *Popanoceras parkeri* beds in the lower Permian or Artinsk, but in this he was mistaken. Prof. W. F. Cummins told the writer that these beds are not in the Upper Cisco, but in the Strawn division, and therefore are Lower Coal Measures.

† Karpinsky, *Ammoneen der Artinsk-Stufe*, p. 92.

‡ *Salt Range Fossils, Geological Results*, p. 204.

The beds of Poteau mountain, Indian Territory, are probably of the age of the Lo-ping strata, while the yellow shales of Scott county, Arkansas, 1 N., 28 W., section 4, southeast quarter of southeast quarter, are probably of the age of the Upper Carboniferous Limestone of Moscow, and the west slope of the Urals,* if we can judge by the occurrence of *Gastrioceras* conf. *marianum* and *Pronorites* in them. This would make them older than the Poteau mountain shales, which is very likely the case. They are the probable equivalents of the Canyon division of Texas.

Paleobotanic Evidence.

Our knowledge of the paleobotany of the Coal Measures of Arkansas has been up to the present time very limited, depending almost entirely on the publications of Lesquereux in the *Second Annual Report of a Geological Reconnoissance of the Middle and Southern Counties of Arkansas*, 1860, and in the *Second Geological Survey of Pennsylvania*, "Report of Progress, P. Description of the Coal Flora of the Carboniferous Formation in Pennsylvania, and throughout the United States," 1884.

The joint monograph† of H. L. Fairchild and David White on the *Fossil Flora of the Coal Measures of Arkansas* throws much new light on the stratigraphic and regional distribution of species, and has been of material aid in correlating the Arkansas strata with those of other regions. They prove that all the Coal Measure plants‡ published from Arkansas belong to the horizon of the Upper or Productive Coal Measures. The Van Buren plant bed is thought from paleobotanic evidence to belong above the horizon from which most of the coal of Arkansas is obtained, that of the Ouita coal, and this agrees with the evidence given by the stratigraphy and the marine fossils. The Van Buren plant bed occurs below the Poteau mountain marine beds, and above those in 8 N., 32 W., section 12, Sebastian county, near Fort Smith; and these latter marine beds occur above the horizon of the Ouita coal.

The Poteau mountain marine beds are of about the same age as the Wyoming Valley limestones§ of the Upper Productive Coal Measures of Pennsylvania, and these belong below the Dunkard creek series of the Upper Barren Coal Measures. The Dunkard creek beds have lately been proved by Prof. I. C. White‖ to be of the same age as the Permian of northern Texas, on the basis of plant remains that occur towards the top of the Texas beds in which marine Permian fossils were found.¶

But the paleobotanic evidence aids in establishing the age of the

* C2 of Tschernischew, *Mém. Com. Géol. Russie*, Vol. iii, No. 4, p. 353.

† An unpublished report of the Geol. Survey of Arkansas.

‡ The work of the Survey shows that the plants described by Lesquereux from Washington county as Subconglomerate belong to the Lower Carboniferous.

§ Upper part of C2, Tschernischew, *Mém. Com. Géol. Russie*, Vol. iii, No 4, p. 353.

‖ *Bull. Geol. Soc. America*, Vol. iii, p. 217.

¶ Bull. 77, *U. S. Geol. Survey*.

Upper Coal Measures only; plants are not reported on from any horizons of the Lower Coal Measures, although they are known from a few localities.

Owen* mentions *Stigmaria ficoides* as occurring at Patterson's mill, near Bee Rock, on Little Red river, White county. In August, 1892, a few plants were found by the Survey in the Bee Rock sandstone near the base of the series and below most of the marine fossils, but none of these could be identified.

Mr. D. McRae, of Searcy, informed the Survey that in 7 N, 7 W., section 4, White county, were found shales containing numerous *Lepidodendra* and ferns. These shales are above the Bee Rock sandstones.

In a well at Dr. Griffin's, 5 N., 10 W., section 5, near El Paso, White county, specimens of *Lepidodendron* were collected by Dr. J. C. Branner, in micaceous flaggy sandstone, thought to be of about the same age as the shales of Searcy. About fifty feet above the flaggy sandstone was found a thin bed of coal, and thirty feet higher was another coal bed with numerous ferns and *Calamites*.

C. S. Prosser† mentions plants supposed to be of Lower Carboniferous age, from Shinall mountain, in 2 N., 14 W., section 17; also from section 20 of the same township.

In quarries in the sandstones of Big Rock, near the city of Little Rock, are found plant remains of indeterminable character. The stratigraphy of the Survey places the three last localities in the Lower Coal Measures, and probably above the fossiliferous sandstones of Bee Rock, on Little Red river.

The Pacific Carboniferous Sea.

Revolution in Devonian Time.

In Paleozoic times there have been many revolutions and alternations of continents and seas, and consequent readjustment of their inhabitants to new surroundings. One of the greatest of these revolutions was that which broke up a large zoölogical province, and put in direct connection regions that before were separated.

Dr. A. Ulrich‡ has shown that in Lower and Middle Devonian the faunas of Bolivia, Brazil, the Falkland Islands and South Africa were very similar to those of North America, and that they were very different from the faunas of Europe and Asia. This state lasted until the end of the Middle Devonian, when the revolution began. Prof. H. S. Williams§ has shown that with the beginning of the Upper Devonian in America there came in a fauna, many species of which were not the direct descendants of those immediately preceding them. This new

* *Second Geol. Reconn. Ark.*, Vol. i, p. 68.

† *Ark. Geol. Survey Ann. Rep.*, Vol. iii, 1890, p. 423.

‡ *Beiträge zur Geologie und Paläont. Südamerika, I*, "Paläozoische Versteinerungen aus Bolivien."

§ *Bull. Geol. Soc. Amer.*, Vol. i, "The Cuboides Zone and Its Fauna."

fauna was, however, closely related to forms known in Europe and Asia, but unlike those of the southern regions. Prof. Williams* afterwards elaborated this theory and followed out closely the changes that were inaugurated towards the close of the Devonian. The culmination of these changes produced the Pacific† Carboniferous sea.

The Carboniferous Sea.

From Chapter v, in Suess' *Antlitz der Erde*, Vol. ii, we get many valuable suggestions as to the outlines of the Pacific Carboniferous ocean. The Subcarboniferous was the time of greatest transgression of sea over the present land areas, while the sea in which the *Fusulina* beds of Europe and America were formed was more circumscribed.

The Waverly group when traced towards the west gradually takes on the character of deep water formations; it is persistent through Nevada and California,‡ and has been shown by the writer§ to have a similar fauna in these two states. The Waverly probably persisted much longer in the west than in the east, for in northern Missouri Dr. C. R. Keyes‖ has observed that in the midst of an undoubted Burlington fauna a well-marked Kinderhook or Waverly fauna reappears. This he explains by Barrande's theory of colonies. It is probably an incursion of the inhabitants of a deeper western sea, where the Waverly had persisted longer, into the shallower eastern waters. The work of the Geological Survey of Arkansas shows that a similar phenomenon occurs in that state. The Fayetteville shale, which is of Warsaw or St. Louis age, contains a fauna that differs markedly from those of the limestones above and below it. A recent paper by Prof. Henry S. Williams¶ shows the occurrence in the Fayetteville shale of several species that occur in a doubtful Upper Devonian or Lower Carboniferous black shale in the White Pine district, Nevada. Along with these Devonian or Waverly species occur others that belong much higher, as *Productus semireticulatus* and *Goniatites* conf. *sphæricus*. Below the Fayetteville shale is the Boone chert, which at the base contains a decided Burlington fauna, and at the top probably belongs to the Warsaw. This has been observed in so many places that there is no possibility of mistake in the sequence of the strata.

We have therefore in Arkansas an incursion similar to that in Missouri, except that in Arkansas the incursion came considerably later. This is evidence that somewhere in the west the Waverly fauna persisted throughout the Osage and possibly a part of the St. Louis. This

* *Proc. Amer. Assoc. Adv. Sci.*, 1892, Section E, Address, "The Scope of Paleontology and Its Value to Geologists."

† See also Tschernischew, *Mém. Com. Géol. Russie*, Vol. iii, No. 4, p. 364, on the physical geographic changes that occurred in Europe towards the end of the Carboniferous.

‡ Zoe, Vol. iii, p. 274, *Proc. Calif. Acad. Sci.*, Oct. 17, 1892.

§ *Journ. Geol.*, Vol. ii, No. 6, Metamorphic Series of Shasta County, California.

‖ *American Journal of Science*, December, 1892, p. 447.

¶ *Amer. Journal of Science*, Vol. xlix, 1895, pp. 94–101.

is in accordance with the phenomenon described by Prof. C. D. Walcott in Monograph viii, U. S. Geological Survey, from the Eureka district, Nevada, where a Waverly fauna occurs three thousand feet above the base of the Carboniferous formation. The same thing has been observed by the writer in the Carboniferous of Shasta county, California.*

The Lower Carboniferous limestones can be traced all through the West and the Mississippi valley, to the base of the Appalachian mountains, where they are replaced by conglomerates and other coarse sediments.

Upper Carboniferous in the West.

Of the Upper Carboniferous all that we know west of Indian Territory takes on a decidedly marine character, containing thick beds of limestones. There are however some thin beds of coal in Texas, and some carbonaceous seams with a few land plants in New Mexico and Nevada. The coal in Texas was probably deposited near the southern shore line of the Carboniferous sea, and the carbonaceous seams in the far West probably belong to the insular areas. The fossils described from the western Carboniferous are all marine, with the slight exception that Walcott† mentions a few specimens of pulmonate Gasteropoda that were found along with brachiopods, corals and land plants, evidently washed in from a distance, since no terrestrial Carboniferous deposits are known near the Eureka district.

The Pawhuski Limestone.

In the the eastern part of Indian Territory are found large deposits of coal in the Upper Coal Measures, but further west the same horizon is represented by marine limestone. In 1892, Mr. H. C. Hoover, of the Geological Survey of Arkansas, found at the Government lime-kiln, three miles northwest of Pawhuski, Oklahoma Territory, Osage agency, a bed of massive limestone about 100 feet thick, lying horizontally on heavily bedded sandstones. The limestone is fossiliferous, but the sandstones are not. The fossils collected were placed at my disposal, and on examination they proved to be;

Spirifer cameratus Morton.
Athyris subtilita Hall sp.
Productus semireticulatus Martin, sp.
Productus nebrascensis Owen.
Productus splendens Norwood and Pratten.
Derbyia crassa Meek and Hayden.

These are plainly of Upper Carboniferous age. The limestones cap the hills in that region, and spread over a great area, but fossils were collected at this place only.

* *Journal of Geology;* Vol. ii, No. 6, pp. 588–612.
† *Mon. viii. U. S. Geol. Survey,* p. 262.

Interchange of Life Between East and West.

The many beds of marine fossils in the Productive Coal Measures are simply transgressions from the western sea, and reach no further east than Pennsylvania and West Virginia. The Appalachian system was the western border of the ancient Atlantis* which separated the European from the Pacific waters, while the great Indo-Australian† continent bounded the Pacific ocean on the south. This ocean must have stretched from the American Coal Measures to Eastern China, the Salt range in India, the Ural mountains on the borders of Russia, and into the Arctic regions, for we find related faunas in all these places. Whatever we have of western European Coal Measure species must have migrated from this direction, since on the east there was no direct communication with European waters. An example of this is *Productus giganteus*‡ Martin, which is common in Europe, and is found in the Lower Carboniferous of the McCloud river, Shasta county, but is not found east of that place, unless *P. latissimus* Sowerby, from Montana, west of the main chain of the Rocky mountains, be an equivalent. Another example is *Omphalotrochus whitneyi* Meek, which was first described from the Carboniferous limestone of Shasta county, California, but is also very common in the Lower Coal Measure limestone (C2) of eastern Russia.§

On the other hand, many species seem to be confined to, or characteristic of, this ocean; among them may be mentioned *Productus cora* d'Orbigny, which Waagen‖ says is not found in Europe, its nearest representative being *Productus riparius* Trautschold; it was however first described from South America.

Goniatites marianus Verneul is found in the Artinsk region of the Urals and in Arkansas. The genus *Pronorites*, while found in western Europe, is rare in it, and is much more common in the Pacific region. *Pronorites* is found in the Artinsk region and in Arkansas, while the ammonite genus *Medlicottia*, the direct descendant of *Pronorites*, is found in the Permo-Carboniferous strata of Sicily, the Urals, the Salt range, and Texas.

It is impossible to suppose that the same genus and species originated at different localities, and since we have both ancestors and descendants in places so widely separated, we can only suppose that there was free interchange of life between those places at that time, or in other words an open sea, on the borders of which these fossiliferous deposits were laid down, and along the margin of which the cephalopods and other marine animals could migrate.

* Suess, *Antlitz der Erde*, ii, p. 17.

† Suess, *Ibid.*, ii, p. 316.

‡ See *Annual Report U. S. Geog. and Geol. Surv. Terr.*, 1883, Part i, p. 132, and *Bull. Geog. and Geol. Surv. Terr.*, Vol. ii, No. 4, p. 354.

§ See *Journal Geol.*, Vol. ii, No. 6, pp. 598–600.

‖ *Pal. Indica*, Salt Range Fossils, Brachiopoda, p. 677.

Replacement of Limestones by Coal-bearing Formations in Western Europe.

On tracing the Upper Carboniferous deposits of the Ural region towards the west, we find the limestones thinning out, and the Coal measures and Culm formations taking their places; we find also that the transgression of marine on terrestrial deposits takes place from the east, just the reverse of what is seen in America.

Land Areas in the West.

It is not thought that the Pacific Carboniferous sea was an unbroken expanse of water in western America; on the contrary there are many evidences of large isolated land areas and archipelagos. Dr. Joseph Le Conte* has argued that the Basin range, during much of Paleozoic and Mesozoic time, was a continent, off the western shores of which the sediments that afterwards became the Sierra Nevada and Coast range were laid down. Clarence King† thought that the great thickness of Paleozoic littoral deposits in the Great Basin region proved the existence of a large body of land further west; he thought that the eastern shore of this continent was in Nevada, and east of this stretched the Carboniferous sea, which covered all but the island chain of the Rocky Mountain region. King‡ further concluded that the Carboniferous in California, west of the old shore line, indicated shallow bays that permitted the western extension of the upper Paleozoic deposits, while the bulk of them was stopped by the bold coast. There are evidences of land areas in the Rocky mountains, Wahsatch mountains, New Mexico, and Nevada, but from the facts now known it seems more probable that these were large islands or archipelagos, rather than continents.

THE PERMIAN PACIFIC OCEAN.

The outlines of the great western ocean can be traced in Permian times also, but with much more circumscribed limits. Open-sea deposits of this age are known in Texas, in the Salt range, on the west slope of the Urals, on the island of Sicily, and in scattering places in Central Asia. In all these the genera are nearly the same, except that the *Arcestes* types are confined to the more southern regions. This similarity indicates plainly a connection of these deposits.

Suess§ argues that the open-sea Permian fauna wandered in from the south, and that the Mesozoic types of ammonites were foreign to the northern regions. Karpinsky,‖ on the contrary, holds that they were autochthonous, at least in the Ural region, since he could trace the descent of all the ammonites except the *Popanocerata* from goniatites that

* *American Journal of Science*, iii, Vol. 16, p. 108.
† *U. S. Geol. Explor. Fortieth Parallel*, Vol. i, p. 534.
‡ *Op. cit.*, p. 535.
§ *Antlitz der Erde*, ii, p. 316.
‖ *Ammoneen der Artinsk-Stufe*, p. 86.

were found in the underlying Carboniferous. As has been already mentioned, the ammonite genus *Medlicottia* is not a foreigner on this side of the Permian Pacific ocean, because its ancestor, *Pronorites*, is found here too.

The Triassic Pacific Ocean.

Our knowledge of the Triassic Pacific ocean is based on the work of Mojsisovics, *Arktische Triasfaunen*.* We find that in this period the American part of the great western ocean has mostly become land, and only on the western border of America do we find marine Triassic beds, in Nevada, California, Idaho, and along the coast region in widely separated places, from Alaska through British America to Peru.

These deposits, with similar faunas, can be traced on the other side of the Pacific from New Zealand, Timor, New Caledonia, to Japan, and Siberia. This sea stretched out on one side over the Himalayas to the eastern Alps, forming what Neumayr† called the "central Mediterranean sea." On the other side the sea stretched up to Spitzbergen, but did not reach the Atlantic region. The Triassic was a continental period for the greater part of the present continents.‡ After the Trias the outlines of the western ocean had changed entirely, and no resemblance to the original boundaries can be traced.

Time of the Ouachita Uplift.

The youngest rocks known to take part in the Ouachita Mountain system belong to the Upper Coal Measures, and the disturbance must have taken place at the border between Carboniferous and Permian. Still, it is not unlikely that deposits of Permo-Carboniferous age may yet be found at some places in the region.

Another fact that makes this time for the uplift probable is that the Permo-Carboniferous beds of Kansas and Nebraska are not of the open-sea type, but belong to the northern European or Zechstein type of deposits. The beds of Texas, presumably of nearly the same age, are of the Artinsk or open-sea facies, and are characterized by the occurrence of ammonites, commingled with ordinary Upper Coal Measure fossils.

This uplift may be of the same age as that movement in the Appalachians§ which cut off the Upper Barren Coal Measures of Pennsylvania and West Virginia‖ entirely from the western sea; in those deposits no marine fossils are found, but only land plants and fresh-water Crustaceans,¶ and a few fresh-water mollusks.

* *Mem. Acad. Imper. Sci. St. Petersbourg*, Tome 33, No. 6.

† *Denkschrift Wiener Akad.*, 1885, "Die geographische Verbreitung der Juraformation."

‡ Suess, *Antlitz der Erde*, ii, p. 147.

§ *Penna. Second Geol. Survey*, P. P., p. 120.

‖ I. C. White, *Bull. 65th U. S. Geol. Survey*, p. 41.

¶ *Penna. Second Geol. Survey*, P. P., Permian Flora, W. M. Fontaine and I. C. White, p. 116.

CORRELATION TABLE OF THE COAL MEASURES OF ARKANSAS.

		ARKANSAS.	INDIAN TERRITORY	TEXAS.	MISSISSIPPI VALLEY	PENNSYLVANIA	CHINA AND OTHER PARTS OF ASIA	RUSSIA AND URAL MTS.	INDIA	SOUTH AMERICA
PERMIAN			Permo-Carboniferous	Permian; Wichita and Albany Series	Permo-Carbonifer's of Kansas & Nebraska	Upper Barren Coal Measures	Bokhara Cephalopod Beds	Kostroma Permian Artinsk Stage	Productus Limestones	Itaitúba Beds
COAL MEASURES OR PENNSYLVANIAN	UPPER COAL MEASURES	Poteau Mountain Marine Beds. . . . Van Buren Plant Beds. . . . . . . Fort Smith Marine Beds . . . . . Ouita Coal Horizon with Plants Boles, Scott County, Beds with *Goniatites marianus* and *Pronorites*. . . .	Productive Coal Measures; Pawhuski Limestone	Cisco	Upper Coal Measures	Upp. Prod. Coal Meas.; Wyoming Valley Limestones	Marine Beds of Lo-ping Productive Coal Measures of China	North. Russia Nova Zembla Upper Carboniferous Limestone	Split Limestones	Plant Beds
	LOWER COAL MEASURES	Morrillton Marine Beds . . . . . Conway County Millstone Grit, with Marine Fossils. . . . . Big Rock, Pulaski County, Plant Beds El Paso, White County, Plant Beds . Searcy, Bee Rock, Marine Beds . . . Searcy, Bee Rock, Plant Beds		Canyon Strawn	Lower Coal Measures	Lower Barren Coal Meas. Lower Prod. Coal Meas. Pottsville Conglomerate		Middle Carboniferous Limestone	Muth Quartzites Limestones	
LOWER CARBONIFEROUS OR MISSISSIPPIAN.		Lower Carboniferous Limestone . .	Lower Carboniferous Limestone	Bend Division	Lower Carboniferous Limestone	Mauch Chunk Series	Lower Carboniferous Limestone	Lower Carboniferous Limestone	Crinoidal	

Descriptions of the Coal Measure Marine Fossils.

The lists of fossils given above establish beyond question the age of the species described in this paper, and enable us, even without the aid of stratigraphy, to assign them to their proper horizon, by a study of the accompanying faunas. Of the goniatites only one, *Gastrioceras branneri* J. P. S., is thought to be a new species, although all are new to Arkansas. *Gastrioceras marianum* Verneul, and *Pronorites cyclolobus* Phillips, have never before been found outside of Europe; *Gastrioceras globulosum* Meek and Worthen is found here for the first time outside of Illinois; *Gastrioceras excelsum* Meek is found for the first time outside of Kansas; *Paralegoceras iowense* Meek and Worthen is found here for the third time, being known elsewhere only in Iowa and in Texas, and shows on the Arkansas specimen the internal lobes, features that have never before been seen in this species and genus.

Both stocks or families are represented in the collection, and genera that probably were the ancestors of important genera and families in the Permian and the Mesozoic, and thus as transitional forms, or links in genetic series, they command especial interest. All species described in this paper are deposited in the geological museum at Stanford University, except the originals of *Gastrioceras branneri* J. P. S., and *Pronorites cyclolobus* Phillips, var. *arkansiensis* J. P. S., which are deposited in the U. S. National Museum.

Subkingdom Coelenterata.

Class *Anthozoa*.

Genus Fistulipora, McCoy. *Fistulipora nodulifera* Meek, *U. S. Geol. Survey Nebraska*, p. 143, Pl. v, Fig. 5.

This species, which is common in the Upper Coal Measures of Nebraska, Iowa, Illinois, etc., was found in corresponding strata on Poteau mountain, Indian Territory.

Genus Lophophyllum, Milne-Edwards and Haime. *Lophophyllum proliferum* McChesney sp., McChesney, *Descript. New Pal. Foss.*, 1860, p. 75; F. B. Meek, *U. S. Geol. Survey Nebraska*, p. 144.

Several specimens agreeing with the typical *L. proliferum* were found in the Upper Coal Measures of Poteau mountain, Indian Territory. Specimens closely resembling this species were also found in the Boone Chert, Lower Carboniferous, of Boone county, 17 N., 19 W., section 2, near Valley Springs. The latter specimens are more like *Lophophyllum proliferum* var. *sauridens* White, C. A. White, *U. S. Geog. Surv. W. of 100th Meridian*, iv, p. 101, Pl. vi, Fig. 4, from Carboniferous strata, New Mexico and Colorado.

Genus Zaphrentis, Rafinesque. *Zaphrentis*, sp. indet.

In Crawford county, 10 N., 30 W., section 10, southeast quarter of northwest quarter, in strata of the Lower Coal Measures, and in the same

formation in Conway county, 5 N., 16 W., section 17, near centre of the north half, were found specimens of this genus, too poorly preserved to allow the species to be determined.

Subkingdom ECHINODERMATA.

Class *Crinoidea*.

Genus CYATHOCRINUS, Miller.

In the Upper Coal Measures of Poteau mountain, Indian Territory were found a great many stems that seem to belong to *Cyathocrinus*, but no other parts were found, to make the identification more certain.

Genus ERISOCRINUS, Meek and Worthen. *Erisocrinus* (*Ceriocrinus*) *inflexus* Geinitz, sp. *Cyathocrinus inflexus* Geinitz, *Carbonformation und Dyas in Nebraska*, p. 62. *Poteriocrinus hemisphæricus* Shumard, *Trans. St. Louis Acad. Sci.*, i, p. 221. *Scaphiocrinus hemisphæricus* Shumard, sp., F. B. Meek, *U. S. Geol. Survey Nebraska*, p. 147. *Erisocrinus* (*Ceriocrinus*) *inflexus* Geinitz, sp., C. A. White, *Twelfth Ann. Rept. Hayden's U. S. Geol. Survey Wyoming and Idaho*, Part i, p. 128, Pl. xxxiv, Fig. 9.

This species which is common in the Coal Measures of Nebraska, Utah, etc., was found in the Upper Coal Measures of Poteau mountain, Indian Territory.

Genus HYDREINOCRINUS, De Koninck. *Hydreinocrinus mucrospinosus* McChesney, sp. *Zeacrinus mucrospinosus* McChesney, *Descr. New Pal. Foss.*, p. 10. *Hydreinocrinus mucrospinosus* McChesney, F. B. Meek, *U. S. Geol. Survey Nebraska*, p. 149.*

Found in the Upper Coal Measures of Poteau mountain, Indian Territory.

Genus POTERIOCRINUS, Miller. *Poteriocrinus*, sp. indet.

In the Upper Coal Measures of Poteau mountain, Indian Territory, were found numerous crinoid stems that seem to belong to Poteriocrinus.

Crinoidea, genus undetermined.

In the Lower Coal Measures of White county, 8 N., 7 W., section 33, southeast quarter, and section 26, southeast quarter, and in beds of the same age in Pope county, Point mountain spur, 10 N., 20 W., section 8, southeast quarter of northwest quarter, were found numerous crinoid stems, which could not be identified since they were mostly in the form of moulds or casts.

* Meek cites this species from Arkansas, but gives no locality, or authority for the statement.

Subkingdom MOLLUSCOIDEA.

Class *Bryozoa.*

Genus FENESTELLA, Lonsdale. *Fenestella shumardi* Prout., *Trans. St. Louis Ac. Sc.*, i, p. 232; F. B. Meek, *U. S. Geol. Survey Nebraska*, p. 153, Pl. vii, Fig. 3.

This species was found in the Upper Coal Measures of Poteau mountain, Indian Territory, and one very closely resembling it, if not identical, was found in the Boone Chert, Lower Carboniferous, at several places in northwestern Arkansas.

Genus RHOMBOPORA, Meek. *Rhombopora lepidendroides*, F. B. Meek, *U. S. Geol. Survey Nebraska*, p. 141, Pl. vii, Fig. 2; C. A. White, *U. S. Geol. Survey W. of 100th Meridian*, iv, p. 99, Pl. vi, Fig. 5.

This Bryozoan is common and characteristic in the Upper Coal Measures of Nebraska, and is found in the same horizon in Utah and Arizona, and was also found in the Upper Coal Measures of Poteau mountain, Indian Territory. The same, or a very similar species, occurs in the Boone Chert, Lower Carboniferous, of northern Arkansas.

Genus SEPTOPORA, Prout. *Septopora biserialis* Swallow, sp. *Synocladia biserialis* Swallow, *Trans. St. Louis Ac. Sci.*, i, p. 179; F. B. Meek, *U. S. Geol. Survey Nebraska*, p. 156, Pl. vii, Fig. 5; C. A. White, *Survey W. of 100th Meridian*, iv, p. 107, Pl. vii, Fig. 3.

This species is common in the Upper Coal Measures, or Permo-Carboniferous, of Nebraska and Kansas, and in the true Coal Measures of Illinois, and in the Upper Carboniferous of Arizona. It has also been found in the Chester and the St. Louis Limestone, Lower Carboniferous, of Illinois. Waagen * says that the true genus *Synocladia* has not been found in America, and that in Europe or Asia it is characteristic of the Permian. He refers the American forms to the genus *Septopora* of Prout.

Class *Brachiopoda.*

Genus ORTHIS, Dalman. *Orthis pecosii* Marcou, *Geol. North Amer.*, p. 48. *O. carbonaria* Swallow, *Trans. St. Louis Ac. Sci.*, i, p. 218. *O. carbonaria* Meek, *U. S. Geol. Survey Nebr.*, p. 173. *O. pecosii* Marcou, C. A. White, *U. S. Geol. Survey W. of 100th Merid.*, iv, p. 125, Pl. ix, Fig. 5. *Orthis*, sp. indet., Meek, *Pal. Cal.*, i, p. 10, Pl. ii, Fig. 5, a, b, c.

A single specimen was found in the Upper Coal Measures of Poteau mountain, Indian Territory; it agrees best with Dr. C. A. White's figures. The species is of frequent occurrence in the Upper Coal Measures of Iowa, Nebraska, Kansas, Illinois, Texas and in the Upper

* *Pal. Indica*, Salt Range Fossils, I. Productus Limestone Fossils, p. 802.

Carboniferous of New Mexico, and in the Lower Carboniferous of California. Dr. C. A. White * mentions a small Orthis, similar to this species, from the Keokuk of Iowa and Illinois. In the Boone Chert, Lower Carboniferous, of northern Arkansas, probably Keokuk, was also noticed a small Orthis of this type, but the preservation was not good enough for the identification to be certain.

Orthis conf. *resupinoides* Cox, *Geol. Surv. Kentucky*, Vol. iii, p. 570, Pl. ix, Fig. 1; C. A. White, *U. S. Geog. Survey West of 100th Merid.*, Vol. iii, Appendix, p. 23, Pl. iii, Fig. 2.

This type of Orthis is exceedingly rare in the Carboniferous, being rather characteristic of the Devonian. *O. resupinoides* is found in the Coal Measures of Kentucky and the Upper Carboniferous of New Mexico. Dr. C. A. White compares the species to *Orthis iowensis* Hall, *O. tulliensis* Vanuxem and *O. propinqua* Hall of the Devonian.

A few poorly preserved specimens were found in White county, 8 N., 7 W., section 33, southeast quarter, east half, in the Lower Coal Measures; also in Conway county, 8 N., 17 W., section 33, northeast quarter of northeast quarter.

Genus DERBYIA, Waagen. *Derbyia crassa* Meek and Hayden. *Orthisina crassa* M. and H., *Proc Ac. Nat. Sci. Phil.*, 1858, p. 260. *Streptorhynchus crassus* M. and H., F. B. Meek, *U. S. Geol. Surv. Nebraska*, p. 174. *Derbyia crassa* M. and H., Waagan, *Salt Range Fossils, Brachiopoda*, p. 592.

This species is widely distributed in the Coal Measures of Kansas, Nebraska, Illinois, Texas, etc., and was found in the Upper Coal Measures of Poteau mountain, Indian Territory, and in the Lower Coal Measures of Conway county, Arkansas, 6 N., 16 W., section 29, southwest quarter of southwest quarter. It is also very common in the Lower Carboniferous of the Mississippi valley.

Genus PRODUCTUS, Sowerby. *Productus cora* d'Orbigny, *Paleont. de l'Amer. Merid.*, 1842, p. 48. *P. cora* d'Orbigny, C. A. White, *Geol. Survey Indiana*, 1883, p. 126, Pl. xxvi, Fig. 1, 2, 3, = *P. prattenianus* Norwood.

This species is almost world-wide in its distribution in the Coal Measures, and is also found in the Productus Limestone of the Salt Range, India. Waagen, in *Paleontologia Indica, Salt Range Fossils, Brachiopoda*, p. 677, says that the true *Productus cora* is probably not found in Europe, its nearest representative being *P. riparius* Trautschold.

In America the typical species is very common in both Coal Measures and Lower Carboniferous. It was found in the former horizon on Poteau mountain, Indian Territory, and in the latter in numerous places; Fayetteville shale, probably Warsaw, Independence county, 13

* *U. S. Geog. Survey W. of 100th Merid.*, iv, p. 126.

N., 6 W., section 13, southeast quarter of southeast quarter, near Moorefield; Marshall shale, probably Warsaw division, Independence county, 12 N, 6 W., section 12, and Stone county, Blue mountain, 14 N., 11 W.; Archimedes Limestone, probably of St. Louis age, Independence county, 12 N., 6 W., section 14.

Marcy (*Expl. Red River of Louisiana*, p. 187) cites this species from Subcarboniferous limestone of Washington and Crawford counties, but does not give the localities.

Productus (*Marginifera*) *splendens* Norwood and Pratten. *Productus splendens* Norwood and Pratten, *Jour. Acad. Nat. Sci. Phil.*, 1854, Vol. iii, p. 11, Pl i, Fig. 5. *P. wabashensis* Norwood and Pratten, *Jour. Acad. Nat. Sci. Phil.*, 1854, p. 13, Pl. i, Fig. 6. *P. longispinus* Meek (non Sowerby), *Final Report U. S. Geol. Survey Nebraska*, p. 161. *Marginifera splendens* N. and P., Waagen, *Palæontologia Indica, Salt Range Fossils, Productus Limestone Fossils, Brachiopoda*, p. 714.

This typical Upper Coal Measure and Permian species is a probable descendant of *Productus longispinus* Sowerby, and so closely are these two related, that for many years they were considered identical. But the *Marginifera* type of Productus seems to be confined to the Upper Carboniferous and Permian, while *P. longispinus* Sowerby is also found in the Lower Carboniferous. The Arkansas specimens agree perfectly with specimens from Indiana and Illinois. This species is very common in the Coal Measures and Permian of North America, and probably occurs also in Asia A very similar small species occurs in the Lower Carboniferous limestone, Stone county, 14 N., 11 W., on Blue mountain, but this lacks the ventral sinus, and has fewer spines, and therefore probably belongs to the true *P. longispinus* Sowerby.

P. (*Marginifera*) *splendens* N. and P. was found in the Upper Coal Measures of Sebastian county, Arkansas, 8 N., 32 W., section 12, and on Poteau mountain, Indian Territory, in strata that are either of uppermost Coal Measure or of Lower Permian age.

Productus punctatus Martin. *Anomites punctatus* Martin, *Petrif. Derb.*, Pl. 37, Fig. 6. *Productus punctatus* Martin, Davidson, *Mon. Brit. Carb. Brachiopods*, p. 172.

This species is cosmopolitan in the Coal Measures and Lower Carboniferous, although more common in the latter horizon. It is very seldom that the shell is so preserved that the internal characteristics can be seen. In the figured specimen the arm impressions, adductor muscle scars, median septum, and the cardinal process are all perfectly preserved.

The dorsal valve is somewhat squarer than those figured by Davidson (*Mon. Brit. Carb. Brach.*, Pl. 44, Figs. 9–17), but the internal markings are the same in every detail, except that Davidson's figure makes the

cardinal process a little longer. The internal characteristics are imperfectly illustrated by McChesney (*Trans. Chicago Acad. Sci.*, Pl. i, Figs. 10, 11).

Occurrence.—Productus punctatus was found in great numbers in the upper part of the Lower Coal Measures of Conway county, 6 N., 16 W., section 29, on the east bank of Arkansas river, about one mile below the Old Lewisburg ferry. It was also found in the Lower Carboniferous at several places in the State.

Productus semireticulatus Martin, sp., *Petrifacta Derbiensia*, p. 7.

This well-known cosmopolitan species was found in the Barren or Lower Coal Measures in White county, 8 N., 7 W., section 33, southeast quarter, and in section 26, southeast quarter. It was also found in the Lower Carboniferous, in the Fayetteville shale, probably Warsaw, in Searcy county, 16 N., 17 W., section 1, southwest quarter of southwest quarter; in the Boone Chert, upper Burlington or lower Keokuk, in Searcy county, 17 N., 18 W., section 28, and at various other places in northern Arkansas; in the Marshall shale, probably Warsaw, in Stone county, on Blue mountain, 14 N., 11 W., south of Mountain View.

Genus RHYNCHONELLA, Fischer de Waldheim. *Rhynchonella uta* Marcou. *Terebratula uta* Marcou, *Geol. of N. Amer.*, p. 58. *Rhynchonella osagensis* Swallow, *Trans. St. L. Ac. Sci.*, 1858, p. 219. *Rhynchonella osagensis*, F. B. Meek, *U. S. Geol. Surv. Nebraska*, p. 179. *Rhynchonella uta* Marcou, C. A. White, *U. S. Geol. Expl. W. of 100th Merid.*, iv, p. 128.

This characteristic Coal Measure species, found in Kansas, Nebraska, Iowa, Missouri, Illinois, Texas and South America (?), was found in the Upper Coal Measures of Sebastian county, 8 N., 32 W., section 12; also in the same horizon on the Poteau mountain, Indian Territory.

Rhynchonella, sp. indet.

In the Lower Coal Measures of White county, 8 N., 7 W , section 33, southeast quarter, and of Crawford county, 10 N , 30 W., section 10, southeast quarter of northwest quarter, were found several Rhynchonellas that could not be specifically determined.

Genus TEREBRATULA Lhwyd. *Terebratula hastata* Sowerby, *Mineral Conchology*, Vol. v, p. 446. *Terebratula bovidens* Morton, *Am. Journ. Sc.*, Vol. xxix, p. 150. *Terebratula bovidens*, F. B. Meek, *U. S. Geol. Surv Nebraska*, p. 187, Pl i, Fig. 7.

Meek (*loc. cit.*) speaks of the strong resemblance of *T. bovidens* to *T. elongata* Schlotheim, sp., and *T. hastata* Sowerby, sp., but is strongly inclined to believe in the specific difference. Davidson (*Monograph Brit. Carb. Brach.*, Appendix, p. 226) is inclined to unite *T. elongata, T. hastata* and *T. sufflata*. If *Dielasma bovidens* is really identical with *T.*

hastata, it is an example of one species ranging from the Devonian up into the Permian. This species ranges through the Coal Measures in Nebraska, Kansas, Illinois, Texas, New Mexico, etc. It is very common in the Upper Coal Measures of Poteau mountain, Indian Territory, and was also found in the Fayetteville shale, Lower Carboniferous, probably Warsaw, of Independence county, 13 N., 6 W., section 13, southeast corner, near Moorefield; also in the Lower Coal Measures of Conway county, 8 N., 17 W., section 33, northeast quarter of northeast quarter.

Genus ATHYRIS, McCoy. *Athyris subtilita* Hall. *Terebratula subtilita* Hall, *Stansbury's Expl. Gt. Salt Lake*, p. 409. *Athyris subtilita* Hall, sp., F. B. Meek, *U. S. Geol. Surv. Nebraska*, p. 180, Pl. i, Fig. 12, Pl. viii, Fig. 4.

This species is found nearly all over the world in the Coal Measures. It is also found in various places in the Lower Carboniferous, as in England and India

It was found to occur frequently in the Upper Coal Measures of Sebastian county, 8 N., 32 W., section 12, and of Poteau mountain, Indian Territory; in the Boone Chert, Burlington or lower Keokuk, of Stone county, 14 N., 10 W., section 9, northwest quarter.

Marcy (*Expl. Red River of Louisiana*, p. 189) cites *Athyris subtilita* from the Subcarboniferous limestone of Washington county.

Genus RETZIA, King. *Retzia radialis* Phillips. *Terrebratula mormonii* Marcou, *Geol. N. Amer.*, p. 51, Pl. vi, Fig. 1. *Retzia punctilifera* Shumard, *Trans. St. Louis Ac. Sci.*, i, p. 220. *Retzia subglobosa* McChesney, *New Pal. Foss.*, p. 45, Pl. i, Fig. 1. *Retzia compressa* Meek, *Pal. Calif.*, i, p 14, Pl. ii. Fig. 7.

R. radialis is common in the Western Coal Measures and Lower Carboniferous; it was found in great numbers in the Upper Coal Measures of Sebastian county, 8 N., 32 W., section 12, and of Poteau mountain, Indian Territory.

Genus SPIRIFER, Sowerby. *Spirifer cameratus* Morton, *Am. Journ. Sc.*, Vol. xxix, p. 150. *Spirifer meusibachianus* Rœmer, *Kreidebildung von Texas*, p. 88. *Spirifer triplicatus* Hall, *Stansbury's Expl. Gt. Salt Lake*, p. 410. *Spirifer cameratus* Morton, C. A. White, *U. S. Expl. W. of 100th Merid.*, iv, p. 132, Pl. x, Fig. 1.

This species is distributed throughout the Coal Measures from Pennsylvania and West Virginia to Arizona; it is also found in the Permo-Carboniferous of Kansas;* Meek, in *Geol. Expl. 40 Parallel*, iv, p. 8, cites the species from the Upper Carboniferous of the White Pine Mining district of Nevada. It was found in great numbers in the Upper Coal Measures of Sebastian county, 8 N., 32 W., section 12, and of Poteau mountain, Indian Territory; also in the Lower Coal Measures

* F. B. Meek, *U. S. Geol. Surv. Nebraska*, p. 184.

of Conway county, 6 N., 16 W., section 29, southwest quarter of southwest quarter.

Spirifer rockymontanus Marcou, *Geol. of N. Amer.*, p. 50, Pl. vii, Fig. 4. *Spirifer opima* Hall, *Geol. Surv. Iowa,* Vol. i, Part ii, p. 711. *Spirifer subventricosa* McChesney, *Desc. New Pal. Foss.*, p. 44. *Spirifer rockymontanus* Marcou, C. A. White, *U. S. G. Expl. W. of 100th Merid.*, iv, p. 134, Pl. xi, Fig. 9.

S. rockymontanus occurs in the Upper Carboniferous from Pennsylvania to New Mexico.

It was found in the Lower Coal Measures of White county, 8 N., 7 W., section 33, southeast quarter, in the form of well-preserved casts, also in section 26, on Bee Rock; also in the same horizon, Crawford county, 12 N., 30 W., section 17. These specimens agree with Dr. White's figures and descriptions so well that no further description is necessary.

Genus SPIRIFERINA, d'Orbigny. *Spiriferina cristata* Schlotheim. *Terebratulites cristatus* Schlotheim, *Beiträge Nat. Verst. Muenchen,* Pl. i, Fig. 3. *Spiriferina kentuckensis* Shumard, *Geol. Surv. Missouri,* 1858, p. 203. *Spirifer octoplicatus* Hall, *Stansbury's Expl. Gt. Salt Lake,* p. 409, Pl. xi, Fig. 4. *Spirifer laminosus* Geinitz, *Carbonformation und Dyas in Nebraska,* p. 45, Pl. iii, Fig. 11. *Spiriferina kentuckensis* Shumard, sp., F. B. Meek, *U. S. Geol. Surv. Nebraska,* p. 185, Pl. vi, Fig. 3, Pl. viii, Fig. 11.

Dr. C. A. White, in *U. S. Geog. Expl. W. of 100th Merid.*, iv, p. 140, egards *S. octoplicatus* Hall and *S. kentuckensis* Shumard as distinct species. C. D. Walcott, *Pal. Eureka District,* p. 218, regards them both, as well as *S. spinosa* Norwood and Pratten, as synonyms of *S. cristata* Schlotheim, sp. If this reference is correct, then the species ranges from the Upper Devonian of the White Pine Mining district into the Upper Carboniferous of the Eureka district.

Davidson (*Monograph Brit. Carb. Brach.*, p. 267) regards *Spiriferina octoplicata* Sowerby, sp., as synonymous with *S. cristata* Schlotheim, sp., which ranges from the Carboniferous into the Permian. Taken in these broader limitations, the species ranges from the Devonian, through the Lower Carboniferous of the West, and through the entire Coal Measures from Kentucky to Nevada.

Hall (*Geol. Survey Iowa,* Vol. i, Part ii, p. 706, Pl. xxvii, Fig. 5) describes and figures *Spiriferina spinosa* N. and P. from the Kaskaskia group of Iowa. He states that *S. spinosa* differs from *S. kentuckensis* in being more robust and in possessing the tubular spines.

But specimens of *S. kentuckensis* from the Upper Coal Measures of Arkansas are equally robust and possess the spines that are thought to be characteristic of *S. spinosa*.

A comparison of specimens from the Upper Coal Measures of Sebas-

tian county, 8 N., 32 W., section 12, shows the perfect resemblance between the two so-called species. There are five distinct but rather rounded plications on each side of the mesial fold and sinus, but no concentric striations or lamellæ were observed. The entire surface is thickly covered with short spines, which seem to be unusually well preserved.

This species was found in the Lower Coal Measures of Conway county, 6 N., 16 W., section 29, southwest quarter of southwest quarter, and in the Upper Coal Measures at the locality mentioned in Sebastian county; also on Poteau mountain, Indian Territory; in the Lower Carboniferous, Boone Chert, upper Burlington or lower Keokuk, at St. Joe, in Searcy county.

Subkingdom Mollusca.

Class *Lamellibranchiata.*

Genus Aviculopecten, McCoy. *Aviculopecten carboniferus* Stevens, *Amer. Journ. Sc.*, Vol. xxv, p. 261.

Two imperfect specimens from the Lower Coal Measures, White county, 8 N., 7 W., section 26, southeast quarter, agree fairly well with the figures and descriptions of this species. Another specimen was found in the Lower Coal Measures of Conway county, 5 N., 16 W., section 17, northwest quarter.

Aviculopecten coxanus Meek and Worthen, *Proc. Acad. Nat. Sc. Phil.*, 1860, p. 453; *Geol. Surv. Ill.*, ii, p. 326, Pl. xxvi, Fig. 6; F. B. Meek, *U. S. Geol. Surv. Nebraska*, p. 196, Pl. ix, Fig. 2.

This species is found in the Upper Coal Measures of Illinois and Nebraska, and was also found in the same horizon on Poteau mountain, Indian Territory.

Aviculopecten germanus Miller and Faber, *Journ. Cin. Soc. Nat. Hist.*, July, 1892, p. 79.

This species was described from the Coal Measures of Elkhorn creek, Kentucky, and was compared by the authors to *A. rectilaterarius* Cox sp., *Geol Surv. Kentucky*, iii, p. 571, Pl. ix, Fig. 2, but it resembles more closely *A. edwardsi* Worthen, *Bull. 2 State Mus. Nat. Hist. of Ill.*, p. 22; both species were founded on left valves, the right being unknown. They are both very similar to *A. segregatus* McCoy, *British Pal. Fossils*, p. 489, Pl. iii, E, Fig. 1, of the Carboniferous limestone of Northumberland, although the latter has from two to three secondary intermediate ribs, instead of one.

A single small left valve was found in the Upper Coal Measures of Poteau mountain, Indian Territory. It agrees in the main points with Miller and Faber's description, except that the intermediate rib is sometimes obsolete, and distinct concentric lines of growth are seen on the shell.

The beak is sharp, and projects beyond the cardinal margin ; the ribs number about twelve, and are rather coarser than those shown in Miller and Faber's figures.

Aviculopecten occidentalis Shumard, *Geol Survey Missouri*, 1855, Part ii, p. 207, Pl. C, Fig. 18.

This species is very common in the Coal Measures from Pennsylvania to Arizona ; in Arkansas it was found in the Lower Coal Measures of Conway county, 5 N., 16 W., section 17, northwest quarter; about four miles southeast of Morrillton, and 6 N., 16 W., section 29, east bank of Arkansas river, about one mile below the Old Lewisburg ferry, in the Lower Coal Measures.

Genus LIMA. *Lima retifera* Shumard. *Lima retifera* Shumard, *Trans. St. Louis Ac. Sc.*, i, p, 214. *Crenipecten retiferus* Shumard, sp., S. A. Miller, *N. Amer. Geol. and Pal.*, 1889, p. 473.

Lima retifera is characteristic of the Coal Measures in Kansas, Illinois, Nebraska, Texas, etc., and was also found in the Upper Coal Measures of Poteau mountain, Indian Territory.

Genus MACRODON, Lycett. *Macrodon carbonarius* Cox, sp. *Arca carbonaria* Cox, *Geol. Surv. Kentucky*, iii, p. 567, Pl. viii, Fig. 5. *Macrodon carbonarius* Cox sp., F. B. Meek, *Pal. Ohio*, ii, p. 334.

This species resembles so closely *M. obsoletus* Meek, *Pal. Ohio*, ii, p. 334, Pl. xix, Fig. 9, as to raise doubts as to their being different species. They are both found in the Coal Measures, in the upper part of which several specimens of *M. carbonarius* were found on Poteau mountain, Indian Territory. This species was also found in the Lower Coal Measures of Conway county, Ark., 5 N., 16. W., section 17, northwest quarter.

Macrodon obsoletus Meek, *Pal. Ohio*, ii, p. 334, Pl. xix, Fig. 2.

This species, which is found in the Coal Measures of West Virginia and Ohio, also occurs in the Upper Coal Measures of Sebastian county. 8 N., 32 W., section 12, and on Poteau mountain, Indian Territory.

Macrodon tenuistriatus Meek and Worthen, *Proc. Chicago Ac. Sc.*, i, p. 17. *Arca striata* Geinitz, *Carb. u. Dyas in Nebraska*, p. 20, Pl. i, Fig. 32. *Macrodon tenuistriatus* M. and W., F. B. Meek, *U. S. Geol. Surv. Nebraska*, p. 207, Pl. x, Fig. 20.

This is a characteristic Upper Coal Measure species, being found in that horizon in Nebraska, Illinois and Iowa ; it is quite common in the Upper Coal Measures of Poteau mountain, Indian Territory.

Macrodon sp.

In the Upper Coal Measures of Crawford county, 10 N , 30 W., sec-

tion 10, southeast quarter of northwest quarter, were found specimens of *Macrodon* too poorly preserved to be identified with any species.

Genus NUCULA, Lamarck. *Nucula parva* McChesney, *Proc. Chicago Ac. Sc*, i, p. 39, Pl. ii, Fig. 8. *Nucula parva* McChesney, Meek and Worthen, *Geol. Surv. Illinois*, v, p. 589.

This diminutive *Nucula*, which is found in the Coal Measures of Illinois, was found in the form of casts in ferruginous shale of the Lower Coal Measures of Conway county, 5 N., 16 W., section 17, centre of the north half, and in similar strata of the Upper Coal Measures in Crawford county, 10 N., 30 W., section 10, northwest quarter.

Nucula ventricosa Hall, *Geol. Survey Iowa*, Vol. i, Part ii, p. 716, Pl. 29, Figs. 4 and 5.

This species is common in both Lower and Upper Coal Measures from Pennsylvania to Texas. In Arkansas it was found in the Lower Coal Measures in Conway county, 5 N., 16 W., section 17, northwest quarter, about four miles southeast of Morrillton.

Genus NUCULANA, Link. *Nuculana* aff. *bellistriata* Stevens.

This specimen, found in the form of a mould, showing very distinctly the hinge teeth and the surface markings, resembles in general form *Nuculana bellistriata* Stevens, *Am. Journ. Sc.*, 1858, Vol. xxv, p. 261, but differs from it in having the concentric ribs much coarser and less numerous.

Locality, Scott county, 1 N., 28 W., section 4, southeast quarter of southeast quarter, in the Upper Coal Measures.

Genus SCHIZODUS, King. *Schizodus cuneatus* Meek, Pl. xxii, Fig. 3. *Schizodus cuneatus* Meek, *Pal. Ohio*, Vol. ii, p. 336, Pl. xx, Fig. 7.

An internal cast from the Upper Coal Measures of Crawford county, 10 N., 30 W., section 10, southeast quarter of northwest quarter, agrees in shape with the species described by Meek from the Lower Coal Measures of Ohio. The strongly elevated beak without any backward curve is very characteristic. It being an internal cast, the obscure lines of growth seen on the specimens from Ohio do not show, but the muscle scar is distinct, and indications of the hinge teeth can also be seen. In *Paleontology of Ohio*, Vol, ii, p. 337, Meek mentions a similar *Schizodus* from the Upper Coal Measures of Nebraska, but thinks it is probably a distinct species, on account of the small size, more nearly central beaks and more prominent central and anterior margins. The specimen from Arkansas really agrees better with this description than it does with the undoubted *Schizodus cuneatus*, but the Nebraska specimen was never figured and named. *Schizodus cuneatus* was also found in the Lower Coal Measures of Conway county, 8 N., 17 W., section 33, northeast quarter of northeast quarter.

Schizodus wheeleri Swallow, Pl. xxii, Fig. 4. *Cypricardia* (?) *wheeleri* Swallow, *Trans. St. Louis Acad. Sci.*, Vol. i, p. 96. *Schizodus wheeleri* Swallow, F. B. Meek, *Final Rept. U. S. Geol. Survey Nebraska*, p. 209.

This species is very common in the Coal Measures from Pennsylvania to New Mexico, in both Upper and Lower Coal Measures. It has been figured and described so often that nothing new can be added. Our specimens agree best with those from Iowa, described by F. B. Meek, *Final Report of the U. S. Geological Survey Nebraska*, p. 209, Pl. x, Fig. 1, c.

Occurrence.—Several specimens, both right and left valves, were found in the Lower Coal Measures of Conway county, 8 N., 17 W., section 33, northeast quarter of northeast quarter, at Cook's stone quarry, near Hattieville. This horizon is in the so-called Millstone Grit, and near the middle of the Lower Coal Measures. All the fossils in these strata are preserved in the form of casts.

Schizodus conf. *amplus* Meek and Worthen, *Proc. Ac. Nat. Sci. Phil.*, 1870, p. 41 ; *Geol. Survey Illinois*, Vol. v, p. 579, Pl. xxvii, Fig. 6.

This large *Schizodus* is found in the Coal Measures of Pennsylvania and Illinois, and an imperfect specimen, probably belonging to the same species, was found in the Lower Coal Measures of White county, 8 N., 7 W., section 33, east half of the southeast quarter, in ferruginous sandstone, on the road from Searcy to Griffin Springs.

Genus Astartella, Hall. *Astartella newberryi* Meek, *Pal. Ohio*, ii, p. 340, Pl. xix, Fig. 1.

This characteristic species is common in the Upper Coal Measures of Poteau mountain, Indian Territory, and in the Lower Coal Measures of Conway county, Arkansas, 8 N., 17 W., section 33, northeast quarter of northeast quarter.

Astartella vera Hall, *Geol. Survey Iowa*, i, Part ii, p. 715, Pl. xxix, Fig. 1.

This species occurs in the Coal Measures of Iowa, Indiana, Illinois and Pennsylvania, and was found in the upper division of the same series on Poteau mountain, Indian Territory.

Genus Pleurophorus, King. *Pleurophorus oblongus* Meek, *U. S. Geol. Surv. Nebraska*, p. 212, Pl. x, Fig. 4.

This was described by Meek from the Upper Coal Measures of Nebraska, and was found in the Lower Coal Measures of Conway county, 5 N., 16 W., section 17, centre of the north half.

Pleurophorus, sp., C. A. White, *Bull. 77 U. S. Geol. Survey*, p 27, Pl. iv, Figs. 5–10.

This *Pleurophorus* was described and figured but not named by Dr.

C. A. White (*loc. cit.*), from the Permian of Texas. No analogous form was found in the true Coal Measures of Texas, which is not at all surprising, since their fauna is so little known. In the Upper Carboniferous* beds of Scott county, Arkansas, 1 N., 28 W., section 4, northeast quarter of southeast quarter, was found a single specimen that agrees perfectly with the *Pleurophorus* of Dr. White. It is nothing unusual to find a Permian species in the Carboniferous, but the identification is uncertain, owing to the poor preservation of Dr. White's original and of the Arkansas specimen.

Genus CONOCARDIUM Bronn. *Conocardium aliforme* Sowerby, sp., Pl. xxii, Figs. 1 and 2. *Cardium aliforme* Sowerby, *Min. Conch.*, Vol. vi, p. 100, Table 552, Fig. 2. *Conocardium aliforme* Sowerby, sp., Bronn, *Leth. Geogn.*, i, p. 420, Pl. iii, Fig. 9. *Pleurorhynchus minax* Phillips, *Geol. of Yorkshire*, p. 210, Pl. v, Fig. 27.

This genus is rare in the American Carboniferous, and especially so in the Coal Measures, being represented there by only two other species, *C. obliquum* Meek and Worthen, *Geol. Surv. Illinois*, Vol. vi, p. 529, and *C. parrishi* Worthen, *Geol. Surv. Illinois*, Vol. viii, p. 112. The former is more nearly related to *C. aliforme*, but differs from it in its much smaller size, greater obliquity of the shell, and shorter hinge line. The surface of *C. oliquum* is marked by narrow radiating ribs, while those of *C. aliforme* are wider than the depressions between them.

The intermediate spaces are occupied by a secondary rib only on the rounded anterior side of *C. aliforme*, while the same thing occurs even on the posterior side of *C. obliquum*. *C. aliforme* also has the hinge line longer, and the space between the incurved beaks wider; also the ribs on the anterior cordate space are much finer, and this area is bounded by a rather distinct carina, being slightly concave near the rounded border, and rising toward the anterior rostrum, which is preserved on some of our specimens. The shell has its greatest convexity at the anterior end, where the broad carina cuts off the cordate area. Behind this is a distinct furrow, which shades off into the posterior compression of the shell, and dies out in a gentle curve toward the rounded gaping margin. The ribs are broader and the concentric growth lines more distinct towards the posterior end. The concentric lines are not visible on the cordate area. The posterior portion of the shell, next to the hinge line, is not ribbed, but marked with fine, radial lines.

Goldfuss, in *Petrifacta Germaniæ*, Part ii, p. 203, Pl. cxlii, Fig. 1. describes and figures *Conocardium aliforme*, but according to McCoy† he has confused two species, one of which is a Devonian species from the Eifel. The true *C. aliforme* is that described by Phillips, *Geol. of Yorkshire*, Vol. ii, p. 210, Pl. v, Fig. 2, as *Pleurorhynchus minax*, of the Carboniferous Limestone, and by Goldfuss, Pl. cxlii, Fig. 1, *e, f, h, i, l,*

* By the stratigraphy these beds are Barren Coal Measures, but the fossils sh ow close relations to the Upper Coal Measures.

† *British Palæozoic Fossils*, p. 517.

and *m*, the others under Fig. 1 belonging to the Devonian species, which McCoy proposes should retain the name *C. hystericum* Schlotheim. Phillips* proposed to transfer the name *C. aliforme* to the Devonian species, but the type originally described by Sowerby under that name is undoubtedly the Carboniferous species.

This species is found all over Europe, in the Carboniferous, chiefly Mountain Limestone, but owing to the confusion that exists on the Continent one cannot usually tell whether this means Upper or Lower Carboniferous or both.

Nine specimens were found in the Lower Coal Measures of Conway county, 5 N., 16 W., section 17, centre of the north half. They were found in a ferruginous shale, and although in the form of casts they show the sculpture of the surface with unusual clearness, even the delicate, wavy growth lines being as sharply defined as on the original shell. The specimens all had a length of more than one inch, the dimensions of the largest being : length, 1.30 inch ; diameter, 0.88 inch ; width of the cordate area, 0.62 inch.

Genus Edmondia de Koninck. *Edmondia nebrascensis* Geinitz, Meek, *U. S. Geol. Survey Nebraska*, p. 214, Pl. x, Fig. 8. *Astarte nebrascensis* Geinitz, *Carbon. und Dyas in Nebraska*, p. 16, Pl. i, Fig. 25.

A few poorly preserved specimens from the Upper Coal Measures of Poteau mountain, Indian Territory, seem to belong to Meek's Nebraska species.

Edmondia unioniformis Phillips, *Geol. Yorkshire*, Vol. ii, p. 209. *Edmondia unioniformis* (?) Meek and Worthen, *Paleont. Illinois*, Vol. ii, p. 346, Pl. xxvii, Fig. 6.

An imperfect cast from the Upper Coal Measures of Illinois was doubtfully referred by Meek and Worthen to the European species. The Arkansas specimens agree fairly well with Meek's figures and much better with his descriptions, except that they have the concentric ribs coarser.

Occurrence.—Numerous casts were found in the Lower Coal Measures, "Millstone Grit," of Conway county, 8 N., 17 W., section 33, northeast quarter of northeast quarter at Cook's stone quarry.

Class *Glossophora.*

Subclass *Scaphopoda.*

Genus Dentalium Linnæus. *Dentalium* conf. *meekianum*, Geinitz, *Carbon. u. Dyas in Nebraska*, p. 13.

This species was described from the Permo-Carboniferous of Nebraska, and was also found in the undoubted Upper Coal Measures of Illinois. Imperfect specimens were also found in the Upper Coal Measures of Crawford county, Arkansas, 10 N., 30 W., section 10, southeast quarter of northwest quarter.

* *Pal. Foss. Cornwall, Devon, and West Somerset*, p. 33.

Subclass *Gastropoda.*

Genus BELLEROPHON. *Bellerophon carbonarius* Cox, *Geol. Surv. Kentucky*, Vol. iii, p. 574, Pl. x, Fig. 2. *B. urii* C. R. Keyes, *Proc. Ac. Nat. Sc. Phila.*, July 31, 1888, p. 14.

In the Lower Coal Measures of Conway county, Ark., 5 N., 16 W., section 17, centre of north half, were found specimens of this characteristic Coal Measure species, but poorly preserved. Better ones were found in the Lower Coal Measures of Conway county, 6 N., 16 W., section 29, southwest quarter of southwest quarter.

Bellerophon crassus Meek and Worthen, *Geol. Surv. Illinois*, ii, p. 385, Pl. xxxi, Fig. 16.

This species is found in the Upper and Lower Coal Measures of Indiana, in the Subcarboniferous and the Coal Measures of Pennsylvania, and the Upper Carboniferous limestone of Nevada, etc. Good specimens of it were found in the Lower Coal Measures of Conway county, Ark., 5 N., 16 W., section 17, centre of the north half.

Bellerophon marcouanus Geinitz, *Carbon. u. Dyas in Nebraska*, p. 7.

This species in the Upper Coal Measures of Kansas, Nebraska and Iowa, in the Coal Measures of Illinois and West Virginia, and was found in the Upper Coal Measures of Sebastian county, Ark., in 8 N., 32 W., section 12.

Bellerophon sp.

In the Lower Coal Measures of White county, 8 N., 7 W., section 33, southeast quarter, and section 26, southeast quarter in the massive sandstone, were found several large imperfect specimens of a *Bellerophon* that resembles *B. crassus*, but it is probably a different species; it is too imperfectly known for specific identification and description.

Genus PLEUROTOMARIA, Defrance. *Pleurotomaria modesta* Keyes, *Proc. Ac. Nat. Sc. Phila.*, 1888, p. 238, Pl. xii, Fig. 2. *P. depressa* Cox, *Geol. Surv. Kentucky*, iii, p. 569, Pl. viii, Fig. 10.

A single specimen of this exceedingly delicate and beautiful species, showing all the markings, was found in the Upper Coal Measures of Crawford county, Ark., 10 N., 30 W., section 10, southeast quarter.

Pleurotomaria conf. *speciosa* Meek and Worthen, *Proc. Ac. Nat. Sci. Phila.*, 1860, p. 459; *Geol. Surv. Illinois*, Vol. ii, p. 352, Pl. xxviii, Fig. 5.

One small imperfect specimen from the Upper Coal Measures of Poteau mountain, Indian Territory, shows the characters of the Illinois species, although very much smaller. The well-defined suture and fine ornamentations are similar on both and serve to make their identity probable.

Pleurotomaria tenuicincta Meek and Worthen, *Proc. Ac. Nat. Sci. Phila.*, 1860, p. 459; *Geol. Surv. Illinois*, Vol. ii, p. 355, Pl. xxviii, Fig. 3.

This species was described from the Upper Coal Measures of Illinois, and a similar specimen was found in the same horizon on Poteau mountain, Indian Territory.

Pleurotomaria harii S. A. Miller, *Seventeenth Annual Report State Geologist of Indiana*, p. 693, Pl. xiv, Figs. 3, 4.

This species was recently described from the Upper Coal Measures of Kansas City, Mo , and until now has not been found anywhere else. It is a very striking form and easily recognized. The rather rounded whorls are about five in number and marked with numerous rather coarse revolving ribs, which show traces even on the cast.

A single cast, and mold showing the surface markings, was found in the Lower Coal Measures, so-called "Millstone Grit," of Conway county, 8 N., 17 W., section 33, northeast quarter of northeast quarter, at Cook's quarry, near Hattieville.

Pleurotomaria sp.

In the Lower Coal Measures of Conway county, 5 N., 16 W., section 17, centre of the north half; in Franklin county, 12 N., 28 W., section 27, southeast quarter of northwest quarter; and in Pope county, on Point mountain, 10 N., 20 W., section 8, southeast quarter of northwest quarter, were found numerous specimens of *Pleurotomaria*, that while they seem to belong to several distinct species could not be more accurately identified. They are all preserved as casts and usually badly weathered.

Genus EUOMPHALUS, Sowerby. *Euomphalus* (*Straparollus*) *subquadratus* Meek and Worthen, *Geol. Surv. Illinois*, Vol. v, p. 605, Pl. xxix, Figs. 12, 13.

This very common species was found in the Lower Coal Measures of White county, Ark., in 9 N., 4 W., section 6, and 9 N., 5 W., section 1, in a soft pinkish sandstone, along with *Phillipsia* (*Griffithides*) *scitula* Meek and Worthen.

Euomphalus (*Straparollus*) sp.

In the Lower Coal Measures of Independence county, Ark., 11 N., 5 W., centre of section 9, was found a specimen of *Euomphalus* that seemed to be different from *E. subquadratus* but could not be determined with certainty.

Genus NATICOPSIS, McCoy. *Naticopsis nana* Meek and Worthen. *Platyostoma nana* Meek and Worthen, *Proc. Ac. Nat. Sc. Phila.*, 1860, p. 463. *Natacopsis nana* Meek and Worthen, *Geol. Surv. Ill.*, ii, p. 365, Pl. xxxi, Fig. 4. *Naticopsis nana* Meek and Worthen, C. A. White, *U. S. Expl. W. of 100th Merid* , iv, p. 159, Pl. xii, Fig. 4.

This characteristic Upper Carboniferous species is distributed from

Illinois to Nevada ; it was found in the Upper Coal Measures of Sebastian county, Ark., 8 N., 32 W., section 12, associated with numerous other fossils characteristic of the same horizon.

Naticopsis sp.

In the Upper Coal Measures of Scott county, Ark., 1 N., 28 W., section 4, southeast quarter of southeast quarter, was found a specimen of *Naticopsis* that resembles somewhat *N. shumardi* McChesney, found by Dr. White in the Permian of Texas, Bull. 77, *U. S. Geol. Surv.*, p. 24, Pl. iii, Fig. 11, but it is too imperfect to justify a reference to this species.

Genus MACROCHEILUS, Phillips. *Macrocheilus* conf. *fusiformis* Hall, *Geol. Surv. Iowa,* i, Part ii, p. 718, Pl. xxix, Fig. 7.

In the ferruginous shale of the Lower Coal Measures of Conway county, Ark., 5 N., 16 W., section 17, centre of the north half, were found a few specimens that probably belong to Hall's Coal Measure species.

Macrocheilus (*Soleniscus*) *primigenius* Conrad, Hall, *Geol. Surv. Iowa,* Vol. i, Part ii, p. 720, Pl. xxix, Fig. 11.

This species is widely distributed in the Coal Measures of the Mississippi Valley states, and was also found in the Lower Coal Measures, in Conway county, Ark., 5 N., 16 W., section 17, centre of the north half.

Genus POLYPHEMOPSIS, Portlock. *Polyphemopsis inornata* Meek and Worthen, sp. *Loxonema inornata* Meek and Worthen, *Proc. Ac. Nat. Sc. Phila.*, 1860, p. 463. *Polyphemopsis inornata* M. and W., *Geol. Surv. Illinois,* ii, p. 374, Pl. xxxi, Fig. 8.

This species, originally described from the Upper Coal Measures of Illinois, was found in the same horizon in Crawford county, Ark., 10 N., 30 W., section 10, southeast quarter of northwest quarter.

Subclass *Pteropoda.*

Genus CONULARIA, Miller (Sowerby). *Conularia* conf. *crustula* White, *XII Am. Rep. U. S. Geol.* and *Geog. Surv. of Terr.*, 1878, p. 170, Pl. xlii, Fig. 4 ; *U. S. Expl. W. of 100th Merid.*, iii, Appendix, p. 28, Pl. iii, Fig. 4.

The genus *Conularia* is not common in the Lower Carboniferous, but is exceedingly rare in the Coal Measures, so much so that Dr. White mentions this species as being the only representative in that series. Dr. White found it in the Coal Measures near Kansas City, and also near Taos, N. M. The species has been found in the Coal Measures of Texas, and also in the Coal Measures of Scott county, Ark., 1 N., 28 W., section 4, southeast quarter of southeast quarter.

Class *Cephalopoda*.

Order *Tetrabranchiata*.

Suborder *Nautiloidea*.

Genus ENDOLOBUS, Meek and Worthen. *Endolobus* (*Nautilus*) *missouriensis* Swallow, sp., Pl. xxi, Figs. 1–3. *Nautilus missouriensis* Swallow, *Trans. St. Louis Ac. Sc.*, 1857, p. 198. *Endolobus missouriensis* Swallow, sp., C. A. White, *Indiana Geol. Survey*, 1883, p. 166, Pl. xxxv, Figs. 1, 2.

This species resembles very closely *Endolobus spectabilis* Meek and Worthen, *Geol. Surv. Illinois*, ii, p. 308, Pl. xxv, Fig. 18, and, as Dr. C. A. White* remarks, almost the only reason for regarding them as distinct species is their occurrence in such different horizons as the Chester Limestone of the Subcarboniferous, and the Coal Measures. Also Dr. White's specimen was poorly preserved, and he thought it might possibly have had the nodes originally. It is really impossible to recognize the species by Swallow's imperfect original description, but Dr. White's description is very useful in determining this species, which in the Coal Measures of Arkansas does not have nodes on the sides of the shell; the difference is all the more probable, because in the Fayetteville shale, Lower Carboniferous, of Independence county, near Moorefield, was found an *Endolobus*, with very strongly marked nodes, resembling, if not identical with, *E. spectabilis*.

This species also resembles *Endolobus* (*Solenocheilus*) *indianensis* Worthen, *Geol. Surv. Illinois*, viii, p. 150, Pl. xxviii, Fig. 1, but on the Arkansas specimens the whorls are more embracing, are broader and not so high.

In *E. gibbosus* Hyatt, *Second An. Rept. Geol. Survey, of Texas*, p. 353, the whorls are much more flattened, and the umbilicus is narrower, and the umbilical shoulder subangular, while in *E. missouriensis* the shoulders are round. In both, as in *E. spectabilis*, in adult specimens the outer whorl embraces nearly one-half of the next inner whorl. The septa are like those of *E. spectabilis*, and are far apart, gently sinuous and deeply concave. The internal lobe is deep and funnel-shaped. The siphon is slightly nearer the internal than the external side, and is slender.

The casts are smooth, but some specimens have the shell partly preserved. It is ornamented with fine, sharp, spiral lines crossed by finer lines of growth, about one-half as far apart as the spiral lines, giving a finely reticulated appearance to the shell; these transverse lines bend sharply backward on the outside of the whorl.

In our collections are septate fragments of specimens that must have been at least four inches in diameter, and the body chamber would have added about one-half of another revolution, so this species attained a diameter of not less than six inches.

* *Geol. Surv. Indiana*, 1883, p. 166.

The best preserved specimens are small, being only the inner whorls of large individuals, since the body chamber is not seen on any of them.

Dimensions of a small specimen, figured on Pl. xxi, Fig. 2:

Dimensions.	MM.
Diameter	28
Height of the last whorl from umbilicus	19
Height of the last coil from the top of the inner whorl	11

Position and Locality.—Several specimens of this species were found in the Lower Coal Measures of Conway county, Ark., 5 N., 16 W., section 17, centre of the north half.

Genus EPHIPPIOCERAS, Hyatt. *Ephippioceras ferratum* Cox. *Nautilus ferratus* Cox, *Geol. Surv. Kentucky*, iii, Fig. 574, Pl. x, Fig. 2. *Ephippioceras ferratum* Cox, A. Hyatt, *Proc. Boston Soc. Nat. Hist.*, 1883, p. 290.

A single large specimen that probably belongs to this species was found in the Lower Coal Measures of Conway county, Ark., 5 N., 16 W., section 17, centre of the north half. Owen, in his *Report on a Geol. Recon. Arkansas*, Vol. i, p. 68, cites *Nautilus ferratus* from a bold point three (?) miles northwest of Searcy, White county. The rocks of that region are now known to belong to the Lower Coal Measures.

Nautilus sp.

In the Upper Coal Measures of Crawford county, Ark., 10 N., 30 W., section 10, southeast quarter of northeast quarter, were found fragments of a *Nautilus* too imperfect even for reference to any of the genera into which the old genus *Nautilus* has been split up.

Genus ORTHOCERAS, Breynius. *Orthoceras cribrosum* Geinitz, *Carbon. u. Dyas in Nebraska*, p. 4. *Orthoceras cribrosum* Geinitz, Meek, *U. S. Geol. Surv. Nebraska*, p. 234, Pl. xi, Fig. 18.

In the Upper Coal Measures of Poteau mountain, Indian Territory, were found specimens of *Orthoceras*, showing the peculiar indentations of surface supposed to be characteristic of this species. The markings seem to be due to the growth of a bryozoön on the shell, for when magnified they show six-sided cells. Meek, *op. cit.*, p. 234, stated his belief that this marking is accidental.

Orthoceras conf. *rushense* McChesney, *New Pal. Foss.*, p. 68. *Orthoceras rushense*, C. A. White, *Bull.* 77, *U. S. Geol. Survey*, p. 22, Pl. ii, Figs. 14–16.

This species was described originally from the Coal Measures of Indiana and Illinois, and Dr. C. A. White found it in the Permian of

Texas. Some imperfect specimens that probably belong here were found in the Upper Coal Measures of Scott county, Ark., 1 N., 28 W., section 4, southeast quarter of southeast quarter.

Orthoceras sp.

A long slender form with very close chamber walls could not be identified with any species known from the Carboniferous, but the specimens found were not perfect enough for specific description.

Locality.—This species was found in the Lower Coal Measures of Conway county, 8 N., 17 W., section 33, northeast quarter of northeast quarter, at Cook's quarry, near Hattieville.

Suborder *Ammonoidea.*

The *Cephalopoda* alone, of all animals, preserve in the individual a complete record of their larval and embryonic history, the protoconch and early chambers being enveloped and protected by the later stages of the shell. And by breaking off the outer chambers the naturalist can in effect cause the shell to repeat its life history in inverse order, for each stage of growth represents some extinct ancestral genus. These genera appeared on the scene in the exact order of their minute imitations in the larval history of their descendants, and by a study of adult forms in the order of their appearance the naturalist finds the key to the stages of growth of later forms, and is thus enabled to arrange species and genera in genetic series. Studied in this way, paleontology becomes a biologic science.

It has long been known that the goniatites were the ancestors of the ammonites, and the researches of Branco, Hyatt and Karpinsky have traced out these lines of descent in many cases, by studying the successive genera of adult shells in comparison with stages of growth in the individual. Each ammonite is known to begin its life as a goniatite, and only by gradually increasing complication to reach the ammonitic stage. This advance took place in some stocks much earlier than in others, since some show ammonitic characteristics even in the Carboniferous, while others persist in their goniatitic characteristics even in the Trias. In the great majority of cases, however, the transition was made near the end of Paleozoic time, that is, somewhere during the Carboniferous or Permian.

Classification of Goniatites.—The goniatites have been divided into two great stocks or families, *Goniatitidæ* and *Prolecanitidæ*, both of which persist from the Devonian to the Permian. This classification, while the best at present possible, is by no means satisfactory, for it is certain that some of the forms ascribed to the *Prolecanitidæ* descended from genera classified as *Goniatitidæ*.

The *Goniatitidæ* of the Carboniferous consist of the genera *Branco*

ceras, *Glyphioceras*, *Gastrioceras*, *Paralegoceras*, *Nomismoceras*, *Pericyclus*, *Dimorphoceras*, with numerous subgenera. They comprise many rough-shelled species, and on this account they are thought by Steinmann* to have given rise to the trachyostracan *Ceratitidæ* and *Tropitidæ* of the Trias. In this opinion also concurs Dr. K. A. von Zittel,† as far as the *Tropitidæ* are concerned, for these, he thinks, have been developed out of *Gastrioceras* and *Pericyclus*.

The *Prolecanitidæ* of the Carboniferous comprise the genera *Prolecanites*, *Pronorites*. *Agathiceras;* all of which live on into the Permian and branch out during that period into a number of genera and subgenera. Some of these genera live on into the Trias, and branch out during that period into numerous families, whose Jurassic and Cretaceous descendants made up the bulk of the cephalopod faunas.

Besides the *Goniatitidæ* and the *Prolecanitidæ* of the Carboniferous, the *Ammonoidea* are represented already in the Coal Measures of America by the families *Arcestidæ*, in *Popanoceras parkeri*‡ Heilprin, of the Strawn division, Lower Coal Measures of Texas.

In the European Coal Measures the *Tropitidæ* are represented by *Thalassoceras looneyi* Phillips. *Thalassoceras* was described by Gemmellaro§ to include certain species of the Carboniferous and Permian, and referred to the *Tropitidæ;* this genus, along with *Paraceltites* Gemmellaro, *Gastrioceras*, and some Permian forms referred to *Glyphioceras*, are said by Mojsisovics‖ to be the Paleozoic representatives of the *Tropitidæ*.

Family *Goniatitidæ* von Buch (Zittel).
Subfamily *Glyphioceratidæ* Hyatt.

This group includes a series of forms that range from the Upper Devonian into the Permian. The older members have the siphonal lobe undivided, thus showing their relationship to the older *Prolecanitidæ*. The form may be compressed and discoidal as in *Brancoceras* of the Devonian and Carboniferous; or broadly rounded and involute, with semilunular cross-section, as in most species of *Glyphioceras;* or evolute, with wide umbilicus, trapezoidal cross-section, and umbilical ribs, as in most species of *Gastrioceras*. The sutures are simple, consisting of a siphonal lobe, which may or may not be divided by a secondary siphonal saddle, and one or two pairs of lateral lobes, which are somewhat pointed, also usually a pair of short lobes on the umbilical shoulders. The internal lobes consist of a long and rather pointed antisi-

* *Elemente der Palæontologie*, 1890, p. 393.

† *Grundzüge der Palæontologie*, 1895, p. 405.

‡ The writer, in *Journ. Geol.*, Vol. ii, No. 2, p. 194, following Karpinsky in *Ammoneen d. Artinsk-Stufe*, p. 92, referred the *Popanoceras parkeri* beds to the Artinsk stage, but Prof. W. F. Cummins, of the Geological Survey of Texas, has pointed out to the writer the true horizon of this species.

§ *Giornale Sci. Nat. Econom.*, Vol. xix, 1888, p. 67.

‖ *Das Gebirge um Hallstadt*, Bd. ii, p. 10

phonal lobe, and a pair of pointed lateral lobes. The saddles, both external and internal are usually rounded, although even they may become angular, as in old specimens of *Glyphioceras sphæricum* Martin. The surface in most of the older members of the group is ornamented only with striæ, but in many, especially the later members, umbilical ribs are developed, which in *Pericyclus* cross the abdomen. Periodic constrictions, or varices, representing temporary cessations of growth, are found on most of the genera.

Hyatt * says that the *Glyphioceratidæ* are derived directly from the group *Magnosellaridæ*, as represented by *Parodiceras* of the Devonian. And, in fact, the development of *Glyphoceras diadema* Goldfuss, as worked out by Branco,† shows at 2.25 millimetres diameter a decided resemblance to the adult sutures of *Tornoceras*. The younger larval sutures of this form show derivation from a radicle like *Anarcestes*. Pl. xix, Fig. 5, shows the development of *Tornoceras* (*Parodiceras*) *retrorsum* Buch, after Branco, in *Palæontographica*, Vol. xxvii, Pl. v, Fig. 7. We thus have probably the complete genealogy of the *Glyphioceratidæ* in the larval stages of the two genera, *Glyphioceras* and *Tornoceras*. Pl. xix, Fig. 4, shows the development of *Glyphioceras diadema* Goldfuss, after Branco, in *Palæontographica*, Vol. xxvii, Pl. iv, Fig. 1.

Genus GASTRIOCERAS, Hyatt.

This genus was originally established by Hyatt (*Proc. Boston Soc. Nat. Hist.*, Vol. xxii, 1883, p. 327) to include evolute species with open umbilicus, trapezoidal or semilunular cross-section, and usually ribs or tubercles on the sides; the species included by Hyatt in this genus all have prominent siphonal saddles, first lateral saddle broadly rounded, second lateral saddle broad but inclined to be pointed; the siphonal lobes are long, narrow and pointed, and the lateral lobes broad and pointed. In all the species cited by Hyatt (*loc. cit.*) as belonging to *Gastrioceras* there is but a single pair of lateral lobes visible, that is, on the sides of the shell; and in the *Second Annual Report Geol. Survey of Texas*, 1891, p. 355, Hyatt limits *Gastrioceras* to forms with a single pair of lateral lobes and with the second pair on the umbilical shoulders. Hyatt (*loc. cit.*) refers *G. russiense* Zwetajew to his genus *Paralegoceras*, because that species has the second pair of lateral lobes on the sides of the shell and not on the umbilical shoulders. But *Gastrioceras russiense* has just the same number of lobes as all other known species of *Gastrioceras*, namely nine in all, and lacks the lobe on the umbilical border, which is characteristic of *Paralegoceras*. Another species, *Gastrioceras baylorense* White (Bull. 77, *U. S. Geol. Survey*, p. 19, Pl. ii, Figs. 1–3), also has two pairs of lateral lobes. White's figures and description do not show whether the umbilical lobe is present or not; if it is, *G. baylorense* rightfully belongs with *Paralegoceras*, but it most probably belongs in

* *Proc. Boston Soc. Nat. Hist.*, Vol. xxii, 1883, p. 322.

† *Palæontographica*, Vol. xxvii, Pl. iv, Fig. 1.

the same group as *G. russiense*. Dr. K. von Zittel, in *Grudzüge der Palæontologie*, 1895, p. 399, confines *Gastrioceras* to forms with a single pair of lateral lobes. But the relations of *Gastrioceras*, *Glyphioceras* and *Paralegoceras* have been best worked out by Karpinsky,* who shows that there is no marked distinction between *Glyphioceras* and *Gastrioceras*; that both have the same number of lobes and saddles—nine of each; that the second pair of lateral lobes may be on the umbilical shoulders or on the sides of the shell, thus differing from *Paralegoceras*, in which the third pair of lateral lobes is on the umbilical shoulders. *Gastrioceras* usually has a trapezoidal cross-section and umbilical ribs; but some species lack the ribs, as *G. globulosum* M. and W., while some species of *Glyphioceras* have umbilical ribs and, in their youth, also the elliptical cross-section, as *Glyphioceras diadema* Goldfuss. But the two extremes are widely separated from each other, as *Gastrioceras jossæ* Verneul and *Glyphioceras sphæricum* Martin.

This genus has been looked upon by Steinmann† as the ancestor of the trachyostracan families of the Trias, the *Ceratitidæ* and the *Tropitidæ*. Dr. K. von Zittel ‡ agrees with this opinion as to the origin of the *Tropitidæ*, but thinks the *Ceratitidæ* developed out of the *Prolecanitidæ*.

Gastrioceras branneri sp. nov. J. P. Smith, Pl. xxiii, Figs. 1–6.

The adult shell is discoidal, with low, narrow whorls of semilunular cross-section; the adult whorl is very evolute, embracing not more than a third of the preceding one, and the increase in height and breadth is extremely slow. The young whorls are proportionally broader and more involute, so that the umbilicus of the younger part of the shell is deeper, but widens rapidly with age, as the involution decreases. *G. branneri* is the most evolute species of *Gastrioceras* known in the Carboniferous, and approaches the narrow evolute Permian type, described by Gemmelaro§ from Sicily; but the Sicilian form still retains the strong constrictions, and has also acquired the spiral striæ that are characteristic of Permian *Gastrioceras*.

Dimensions.	MM.
Diameter	39.5
Height of last whorl	10.5
Width of umbilicus	19.0
Breadth	15.0
Height of last whorl from top of preceding	8.0

The specimen shows nine whorls at the diameter of 39.5 mm.

Sutures.—The sutures consist of three external lobes and as many

* *Mém. Acad. Impér. Sci.*, St. Petersburg, vii Ser., Tome xxxvii, No. 2, "Ammoneen d. Artinsk-Stufe," pp. 45–48.

† *Elemente d. Palæontologie*, 1890, p. 393.

‡ *Grundzüge d. Palæontologie*, 1895, p. 405.

§ *Giorn. Sci. Nat. ed. Econ.*, Vol. xx, 1890, p. 31, Pl. D, Figs. 21–26, *Gastrioceras waageni* Gemm.

saddles. The siphonal lobes are long, narrow, and pointed; the first lateral broadly pointed, and on the umbilical shoulder is another shallow lobe, broad and pointed. The siphonal saddle is narrow, with the usual indentation at the end; the first lateral saddle is broadly rounded and deep, the second lateral saddle shallow and inclined to be pointed. The inner lobes are three in number, a long, narrow, pointed antisiphonal lobe, and a pair of shorter, pointed lateral lobes; the four internal saddles are rounded. The figures on Pl. xxiii, Fig. 5, *a* and *b*, show the sutures to be characteristic of *Gastrioceras;* but the second lateral lobe, while on the umbilical shoulders, is plainly visible from the outside. Thus the species might be referred to the genus *Paralegoceras* of Hyatt; but it has only nine lobes and nine saddles, while *Paralegoceras* has eleven of each. For a discussion of this see p. 256 under description of the genus *Gastrioceras*.

Surface Characters.—The shell is preserved on only a small portion of the specimen, but the cast shows the generic and specific characters quite as well. Obscure and somewhat doubtful constrictions were observed, but the preservation is such that their interval could not be ascertained. The umbilical shoulders are marked with rather weak nodes or ribs, which on the outer whorls reach up nearly to the abdominal shoulders; on the young shell they are relatively much stronger.

Affinities.—*Gastrioceras branneri* belongs to the group of *G. listeri* Martin, *G. jossæ* Verneul, and *G. marianum*, all characterized by trapezoidal cross-section, umbilical ribs, pointed lobes and rounded saddles, and evolute whorls. From the above-mentioned species *G. branneri* differs in the narrowness of its whorls, and wide, shallow umbilicus; it seems to depart further from the *Glyphioceras* stock than any other Carboniferous species of the genus *Gastrioceras*.

Occurrence.—*Gastrioceras branneri* was found along with *Pronorites cyclolobus* Phillips, var *arkansiensis* J. P. Smith, in Arkansas, on Pilot mountain, Carroll county, three and a half miles southwest of Valley Springs, in 17 N., 19 W., section 18, northeast corner, in the Lower Coal Measures, so-called "Millstone-Grit" (A10 of Prof. H. S. Williams' section). About fifty-five feet below this horizon lie coarse, reddish brown, fossiliferous limestone supposed to be the Chester beds of the Lower Carboniferous.

The type, for the use of which the writer is indebted to Prof. H. S. Williams, is the property of the U. S. Geological Survey (National Museum), catalogue number Sta. 1275.

Gastrioceras globulosum Meek and Worthen. Pl. xviii, Figs. 1–6. *Goniatites globulosus* Meek and Worthen, *Proc. Acad. Nat. Sci. Phila.*, 1860, p. 47. *Goniatites globulosus* Meek, *Geol. Surv. Illinois*, ii, p. 390, Pl. xxx, Fig. 2. *Gastrioceras globulosum* M. and W., sp , A. Hyatt, *Proc. Boston Soc. Nat. Hist.*, 1883, p. 327.

This species resembles *Goniatites* (*Gastrioceras*) *baylorensis* White, of

the Texas Permian, but the lobes of the latter are alone sufficient to separate the species, exceeding by one the number on the sides of *G. globulosum*. The Texas species also has the umbilicus much wider and more open, and is not so globose.

The angle of the umbilicus is 45°, which remains constant notwithstanding the fact that the shell grows more involute with age, being in its youth a comparatively open coil. In youth the whorls are flattened, but with age they become more rounded, until the shell reaches almost the form of *Glyphioceras sphæricum* Martin. As many as six whorls are known.

The deeply marked constrictions, that are so common in the family of the *Glyphioceratidæ*, are seen on the casts, about four to a whorl.

Sutures.—The sutures show nine lobes and nine saddles; the siphonal lobes are narrow and pointed, the first lateral lobe is broad, but pointed, and on the umbilical shoulder is a small, pointed "suspensive" lobe. There are three pointed, internal (concealed by the involution) lobes, of which the antisiphonal (dorsal) is the longer.

The siphonal saddle is rather deeply notched, long and narrow; the two lateral saddles are broad and rounded. The two internal saddles are rather pointed and long, as is the case with most species of this genus. The internal lobes and saddles have never been seen before in this species.

The septa are exactly like those figured by Meek and Worthen, so that no further description of them is necessary; they are typical of the genus *Gastrioceras*, as characterized by Hyatt, although, as Karpinsky* remarks, the sutures alone are not sufficient to separate the genera *Glyphioceras*, and *Gastrioceras*, since a comparison of the sutures of *Gastrioceras jossæ* Verneul and *Glyphioceras diadema* Verneul (not Goldfuss) shows the almost perfect similarity of the two.

The surface of the shell was unknown to Meek and Worthen, but some of the Arkansas specimens have the shell partially preserved. It is marked with fine, sharp, doubly arcuate, sickle-shaped striæ or ribs, with the sinus on the ventral portion pointing backwards. This surface ornamentation resembles that of *Glyphioceras obtusum* Phillips, *Geol. of Yorkshire*, ii, p. 235, Pl. xix, Figs. 10–13, but the form is much more globose, and the lobes unlike those of Phillips' species.

Dimensions.—One of the fragments shows a diameter of over two inches; on this only the body whorl was seen, it being at least one coil in length.

Dimensions of the Largest Figured Specimen.

	MM.
Diameter	36
Breadth	27
Height of last whorl	14

*"Ueber die Ammoneen der Artinsk-Stufe," *Mém. Ac. Imper. Sci. St. Petersburg*, vi Series, Tome xxxvii, No. 2, p. 46.

	MM.
Height of last whorl from centre of umbilicus	19
Height of last whorl from top of the inner one.........	8
Width of umbilicus	9

These measurements show the adult shell to be very globose.

Position and Locality.—Several specimens of this very interesting species were found in the Upper Carboniferous of Scott county, Arkansas, 1 N., 28 W., section 4, southeast quarter of southeast quarter, in beds supposed to belong to the Barren Coal Measures; but from this and associated fossils seem more likely to belong to the Upper Coal Measures. This species is also found in the Cisco division of the Texas Upper Coal Measures.

Gastrioceras excelsum Meek, Pl. xvii, Fig. 1. *Goniatites globulosus* var. *excelsus* Meek, Bull. *U. S. Geol. and Geog. Survey Terr.*, No. 6, second series, p. 445. *Goniatites globulosus* Meek and Worthen (pars), *Geol. Surv. Illinois,* Vol. ii, p. 390, Fig. 38.

This species was originally described from the Upper Coal Measures of eastern Kansas, from Osage, associated with *Spirifer cameratus* Morton, and *Athyris subtilita* Hall, and other species characteristic of that horizon.

It resembles closely in everything but size *Gastrioceras globulosum* Meek and Worthen of the Upper Coal Measures of Illinois, and we know too few specimens of the latter species to say that it did not grow to the immense size of the Kansas species.

In the Lower Coal Measures of Pope county, Arkansas, 10 N., 20 W., section 8, southeast quarter of northwest quarter, was found a large septate fragment of a specimen that must have been five or six inches in diameter, since the body chamber is at least one coil in length on all nearly related species. The ventral (external) portion of the shell is higher and not so rounded as in *G. globulosum,* but as has already been noticed on that species the coil becomes with age rounder and more elevated, and this may be only an advanced stage of growth not seen on any of the smaller specimens. The lobes are almost exactly like those of the small *Gastrioceras globulosum* of Meek and Worthen.

Gastrioceras marianum Verneul, Pl xvi, Figs. 1–5. *Goniatites marianus* Verneul, *Geol. of Russia,* ii, p. 369, Pl. xxvii, Fig. 2. *Goniatites jossæ* Verneul (pars), Eichwald, *Leth. Ross.*, i, p. 1324. *Goniatites listeri* Martin (pars), var. *mariæ*, Gurow, *Abhandl. d naturf. Gesell. Charcow,* 1873, p. 87. *Gastrioceras marianum* Verneul; Karpinsky, *Ammoneen der Artinsk-Stufe,* p. 49.

This is easily distinguished from all other American species by its low, broad whorl, wide and deep umbilicus, and the strong ribs on the umbilical shoulders. These together with its sutures make it a most typical

representative of the genus *Gastrioceras*. But there are species of *Gastrioceras* that are globose and not flattened, and without the umbilical ribs or nodes ; also certain species have their sutures very angular. On the other hand certain species of *Glyphioceras* have weak umbilical nodes and rounded sutures.

This species is so closely related to *Gastrioceras listeri* Martin, sp., *Petrif. Derb.*, Pl. xxxv, Fig. 3, that they have been united by Gurow. Others still are inclined to unite it with *Glyphioceras diadema* Goldfuss, while many would join it with *Gastrioceras jossæ* Verneul.

From *G. jossæ* it differs in the almost total absence of spiral ribs or striæ, and in the wider and more angular umbilicus, but they are so similar that *G. marianum* may be considered the ancestor of *G. jossæ*.

The best mark of separation from *G. listeri* is the greater number of coils which *G. marianum* has, as many as seven being known on a specimen of less than one inch in diameter.

G. kingii Hall and Whitfield, *U. S. Expl. Fortieth Parallel*, iv, p. 279, Pl. vi, Fig. 9–14, is a closely related form, but differs in having the umbilical slope a little more gentle, the angle with the axis of the shell being 40–45°, while that of *G. marianum* is about 37°. *G. kingii* has fewer whorls to the same diameter. *G. marianum* also has the external saddle not so deeply divided, and the two siphonal lobes are wider and become somewhat broadened at the ends. The ribs on the sides of *G. marianum* are much stronger. Weak spiral striæ are seen on the inner whorls.

The transverse lines of growth form incipient undulations on the ventral portion of the shell. Strong constrictions occur both on the cast and on the shell, on the body chamber, as well as on the rest of the chambers, becoming weaker with age ; their number is about three to a whorl, and they curve forward, with a gentle sinus pointing backward.

The ribs are strong on the sides, forming sharp nodes or tubercles, and are continued across the ventral portion by fine undulations. Towards the centre or umbilicus the ribs weaken very suddenly. The sutures are like those figured by Verneul, but show also the small "suspensive" lobe on the umbilical border, as described and figured by Karpinsky.

The body chamber is at least one coil in length.

Dimensions.—Some fragments indicate a size of not less than two and a half inches in diameter. The most perfect specimen has the following dimensions :

	MM.
Height of last whorl	9
Diameter	30
Width of umbilicus	14

The breadth of the last whorl is about two-thirds of the diameter of

the shell. Angle of umbilicus with the axis of the shell about 37°. These measurements agree very well with those given by Karpinsky.

The smallest of the Arkansas specimens gave the following dimensions:

	MM.
Diameter	8.5
Height of last whorl	2.5
Width of umbilicus	4.5
Breadth of last whorl	6.0

These measurements agree closely with the measurements Karpinsky gives of small specimens from the Urals. The proportions would be

Diameter	1.00
Height of last whorl	0.29
Width of umbilicus	0.53
Breadth of last whorl	0.70

These proportions agree very well with those given by de Verneul, *Geol. Russie d'Europe et des Mont. de l' Oural*, Vol. ii, p. 369.

Occurrence.—This species was originally described by Verneul from the Upper Carboniferous limestone of Schartymka in eastern Russia, C2, and does not occur in the Artinsk or Lower Permian deposits, although it has been confused by many authors with *Gastrioceras jossæ*, which is characteristic of those strata. Karpinsky, in his monograph on the *Ammoneen der Artinsk-Stufe*, pp. 50 and 51, describes the differences that separate *G. marianum* from *G. jossæ* and *G. listeri;* the most striking of these distinctions is that on *G. marianum* the constrictions have a weak sinus pointing backward, while on the others it is forward.

We have therefore at least some evidence of an Upper Carboniferous sea, stretching from the Ural mountains eastward to the Mississippi valley. This would help to explain the fact that our marine Carboniferous fauna has more analogy to the Asiatic than to the western European fauna of the same age.

G. marianum was found in the Upper Coal Measures in Scott county, Ark., 1 N., 28 W., section 4, southeast quarter of southeast quarter. This, or a very closely related species, occurs also in the Cisco division of the Upper Coal Measures of Texas.

Gastrioceras, sp. indet. Pl. xx, Fig. 1.

In the young stages this species resembles closely *G. marianum* Verneul, but the umbilicus is narrower. The young whorl has also a trapezoidal cross-section, each succeeding whorl becoming more highly arched, until all resemblance to the Ural species is lost in the adult stage.

The coil, too, shows decidedly the phenomenon called by Mojsisovics

"egression," by which is meant a change in the direction of the spiral accompanied by widening of the umbilicus, so that with age it flares open. Even with the wide umbilicus of the adult stage, this species is easily distinguished from *G. marianum* by its narrower and more highly arched whorls.

The sides of the whorl are ornamented with strong tubercles, which on the young stages are like those of *G. marianum*, but on the adult form ribs reach halfway from the umbilical shoulders to the ventral portion of the shell.

Constrictions are seen on the cast, about three or four to a revolution. The surface of the shell is not known. The sutures are like those of *G. marianum*, but the siphonal or external lobes are somewhat broader, and the lateral lobes are longer, narrower and more pointed.

The lateral saddle is broad, rounded and considerably shorter than the lateral lobes. There is also a small auxiliary or "suspensive" lobe on the umbilical shoulders, like that of *G. marianum*. The sutures resemble still more closely those of *Glyphioceras diadema* Goldfuss as figured and described by DeKoninck in *Description des Animaux Fossiles Terr. Carbonif. Belgique*, p. 574, Pl. 1, Fig. 1, e. But the Belgian species is considerably more involute, has a lower whorl, and proportionally narrower umbilicus. Also the umbilical ribs are much weaker than on the Arkansas species.

Verneul, in *Géol. Russie d'Europe et des Mont. Oural*, Vol. ii, p. 367, has described a goniatite as *G. diadema*, but this form is less like the Arkansas species than the Belgian form. In addition to this, there is no likelihood that all the forms referred to *G. diadema* are really one species. It is quite possible that the Arkansas species may be identical with one of the many varieties ascribed to *G. diadema*, but at present it is impossible to prove this.

Occurrence.—Several badly broken casts and moulds were found in the Upper Coal Measures of Scott county, Arkansas, 1 N., 28 W., section 4, southeast quarter of southeast quarter, associated with *Gastrioceras marianum* Verneul, *G. globulosum* Meek and Worthen, *Pronorites* sp., etc.

Genus PARALEGOCERAS, Hyatt. *Paralegoceras iowense* Meek and Worthen, Pl. xix, Figs. 1–3. *Goniatites iowensis* Meek and Worthen; *Geol. Surv. of Illinois*, Vol. ii, p. 392, Pl. xxx, Fig. 3. *Paralegoceras iowense* M. and W., Hyatt, *Proc. Boston Soc. Nat. Hist.*, Vol. xxii, 1883, p. 327. *Paralegoceras iowense* M. and W., Hyatt, *Geol. Survey of Texas, Fourth Ann. Report*, 1893, p. 474, Figs. 52–55. *Goniatites missouriensis* Miller and Faber, *Journ. Cincin. Soc. Nat. Hist.*, Vol. xiv, p. 164, Pl. vi, Fig. 1.

The genus *Paralegoceras* is extremely rare, being known heretofore only from the Coal Measures of Iowa, the Upper Carboniferous and Artinsk beds of Russia, and the Bend Formation of Texas, and in the Upper Coal Measures near Kansas City, Missouri.

The Arkansas specimen is a septate cast that when complete must have been at least four inches in diameter. The whorl is broader and rounder than on the Iowa specimen, but this is to be expected on a young individual since the evolution of most of these forms takes place after this manner. The whorls are quite involute and the umbilicus is narrow on the young shell, becoming wider as the shell grows older. The surface of the cast is smooth, no constrictions or other ornamentations appearing on the older shell. But on the younger shell the umbilical shoulders show faint ribs, that shade off into fine undulations on the sides. Hyatt has shown the same thing in *Geol. Survey Texas, Second Ann. Report,* p. 355. But in Texas specimen the ribs persist to a much later stage than on that from Arkansas.

Dimensions.—Although the specimen was not well preserved, the measurements of the entire form could be taken. They were as follows:

	MM.
Diameter	55.5
Height of last whorl from umbilicus	25.5
Height of last whorl from top of inner whorl	17.0
Width of umbilicus	13.5

An inner coil taken out of the same specimen gave the following measurements:

	MM.
Diameter	28.5
Height of last whorl from umbilicus	12.0
Height of last whorl from top of inner whorl	7.5
Width of umbilicus	6.0

These show the inner coils to be much lower, less highly arched, and less embracing than the outer ones.

Surface Markings.—On the inner whorls a trace of the shell is preserved, and is like that figured by Hyatt. The undulating striæ are like those common on the *Glyphioceratidæ.*

Sutures.—The sutures are like those figured by Meek and Worthen, but the siphonal saddle is notched by a small siphonal lobe. The three external lateral saddles are broadly rounded, while the lobes are sharply pointed. The lobes are eleven in number, three on each side, one on each umbilical shoulder (suspensive lobe) and three internal, that is, covered by the involution. The interior lateral lobes and the antisiphonal lobe (dorsal) are very sharp and long. These have not been seen before on this species. The sutures approach very closely to those of *Gastrioceras russiense* Zwetajew, but *Paralegoceras iowense* has one more pair of lobes than the Russian species and has also a suspensive lobe on the umbilical shoulders. In the latter characteristic *Paralegoceras iowense* resembles *P. tschernyschewi* Karpinsky (*Ammoneen der Artinsk-Stufe,* p. 62, Pl. iii, Fig. 1). Karpinsky (*loc. cit.*), has emended Hyatt's

genus to embrace those forms with two lateral lobes and a "suspensive" lobe on the umbilical shoulders. Hyatt, in the *Geological Survey of Texas, Second Annual Report*, 1891, p. 355, emended the genus *Paralegoceras* to include those forms with the second lateral lobe on the umbilical shoulders, and he included in it *Gastrioceras russiense* Zwetajew. But the Russian species has the suspensive lobe on the side and has only nine lobes in all, and thus ought to remain in the group characterized as *Gastrioceras*.

In the *Fourth Annual Report of the Geological Survey of Texas*, 1893, p. 474, Hyatt has described under the name of *Paralegoceras iowense* Meek and Worthen, a goniatite from the Bend Formation of Texas. But the lobes are not exactly like those of the Iowa Coal Measures species, the third lateral saddle is on the umbilical shoulders, and the young shell is marked with ribs which form well-defined tubercles, even on the older shell. These differences were explained by the supposition that the Texas specimen was the young of *Paralegoceras iowense*, and might thus naturally show them. But since the Arkansas specimen is a young one and still shows all the characteristics of the adult, it becomes very likely that the Texas specimen belongs to another species.

There is also another reason why this is probable. The Bend Formation is called Coal Measures by the Geological Survey of Texas, but its fauna seems to be identical with that of the Fayetteville shale of Arkansas, which belongs to the Lower Carboniferous, and probably to the Warsaw or St. Louis division. Species that are almost certainly identical with *Glyphioceras incisum* Hyatt and *G. cumminsi* Hyatt have been collected in the Fayetteville shale of Arkansas. And since these goniatites have unusually only a limited stratigraphic range, it is very probable that the species from the Bend Formation is not identical with that from the Coal Measures.

Occurrence.—A single specimen of *Paralegoceras iowense* was found in Arkansas, in the Lower Coal Measures of Conway county, 5 N., 16 W., section 17, near centre of north half. The species was originally described from the Coal Measures of Iowa and since then has not been cited from any other locality up to the present occurrence, unless the Texas species of Hyatt should be the same. There can, however, be very little doubt that *Goniatites missouriensis* Miller and Faber (*Journ. Cincinnati Soc. Nat. Hist.*, Vol. xiv, p. 164, Pl. vi, Fig. 1), from the Upper Coal Measures of Missouri, near Kansas City, is identical with *Paralegoceras iowense* Meek and Worthen.

Family *Prolecanitidæ* Hyatt.

The *Prolecanitidæ*, as originally described by Hyatt,* included certain elements that do not belong to this stock; but, as revised by Karpinsky,† it forms the most perfect genetic series known, radiating from

* *Proc. Boston Soc. Nat. Hist.*, Vol. xxii, p. 331.

† *Ammoneen der Artinsk-Stufe*, pp. 41–45.

the common radicle, *Ibergiceras*, in several parallel series or subfamilies, including the *Medlicottinæ*, the *Noritinæ*, and the *Lecanitinæ* of the Permian and Trias, the *Pinacoceratidæ* of the Trias, and the *Amaltheidæ* of the Trias, Jura and Cretaceous.

Dr. K. von Zittel* says that this family probably also gave rise to the *Ceratitidæ* of the Permian and Trias.

Genus PRONORITES, Mojsisovics.

In the adult stage *Pronorites* is discoidal, has high, narrow whorl, with nearly parallel sides, is very involute, and has narrow umbilicus.

The siphonal lobe is three-pointed, the first lateral lobe divided into two or three parts by secondary sinuses. In addition to these there are several auxiliary lateral lobes, three to six, all slightly pointed, while all the saddles are rounded. No constrictions or other surface ornamentations are known, except that on the adult body-chamber faint ribs have been observed.

The first septum of *Pronorites* is latisellate, and the broad sinus is soon divided by a siphonal lobe into two lateral sinuses (Pl. xxiii, Fig. 7). This is the end of the embryonic stage, in which the shell is seen to belong to an ammonoid cephalopod, but the family is not yet indicated.

In the next stage the lateral sinuses are subdivided by broad, rounded lobes; the sutures then resemble those of *Goniatites* (*Ibergiceras*) *tetragonus* Roemer of the Upper Devonian, and the shell is in the beginning of the larval or nepionic stage (Pl. xxiv, Fig. 9*a*); a little further on the sutures are like those of a *Prolecanites* (*P. serpentinus* Phillips), and the larval stage is approaching its end.

In the following or neanic stage the siphonal lobe becomes three-pointed, and the shell corresponds to *Paraprolecanites* Karpinsky,† and its family affinities are beyond doubt (Pl. xxiv, Fig. 9*b*).

With the adult or ephebic stage the first lateral lobe becomes divided into two or three parts (Pl. xxiv, Fig. 9*c–f*). With this stage the genus *Pronorites* stops. But Gemmellaro‡ has described from the Permian of Sicily a further development of this form in the genus *Parapronorites*, in which the double lateral lobe and some of the simple ones become serrated.

Another line of development of *Pronorites* has been described by Gemmellaro (*op. cit.*) as *Sicantes*, in which all the lateral lobes become double like the first one. The next higher stages are given by *Medlicottia* Waagen, in which the siphonal saddles become indented and ammonitic. Karpinsky§ shows that *Medlicottia* in its development goes through the *Ibergiceras*, *Prolecanites*, *Paraprolecanites*, *Pronorites*, *Sicanites* and *Promedlicottia* stages.

* *Grundzüge der Palæontologie*, 1895, p. 400.

† *Ammoneen der Artinsk-Stufe*, p. 7.

‡ *Fauna Calc. Fusulina d. Valle d. flum Sosio*, 1887, p. 60.

§ *Ammoneen der Artinsk-Stufe*, p. 41.

Thus the finding of *Pronorites* in Arkansas is of great importance, since it is the ancestor of a form *Medlicottia*, which though unknown in Arkansas, has been found at no great distance away in the Texas Permian.* *Pronorites*, on the other hand, has not yet been found in Texas.

These occurrences help to prove the continuity of life from the Carboniferous into the Permian, and to show that the same conditions existed here as in the Artinsk region of the Ural mountains, where the Carboniferous beds contain the goniatites out of which most of the Permian ammonites were developed.

Pronorites cyclolobus Phillips, variety *arkansiensis* J. P. Smith, Pl. xxiv, Figs. 1–4. *Goniatites cyclolobus* Phillips, *Geol. Yorkshire*, Vol. ii, p. 237, Pl. xx, Figs. 40–42. *Goniatites cyclolobus* Phillips, Verneul, *Geol. Russia and the Ural Mountains*, Vol. ii, p. 370, Pl. xxvi, Fig. 4. *Goniatites cyclolobus* Phillips, Roemer, *Palæontographica*, ix, p. 167, Pl. xxvii, Fig. 1. *Goniatites cyclolobus* Phillips, DeKoninck, *Faune calc. Carb. Belg.*, Vol. ii, p. 121, Pl. 1, Figs. 5, 6. *Pronorites cyclolobus* Phillips, (variety *uralensis*) Karpinsky, *Mém. Acad. Impér. Sci. St. Petersbourg*, vii series, Tome 37, No. 2, p. 8, Pl. i, Fig. 4.

Phillips' original description of *Goniatites cyclolobus* is as follows: "Discoid, sides flat, back broad, inner whorls half concealed, septa with four round lateral lobes, a small double dorsal lobe, and small acute dorsal sinuses, the first lateral sinus double, the others simple, all round."

This description is too meagre to be of more than generic value, and also the term "dorsal" is used where now "abdominal" is in common use.

The shell is smooth, discoidal, very involute. The sides are nearly parallel and the breadth increases very slowly; the abdominal shoulders are nearly square, and the abdomen flat. The whorls are deeply embracing and increase rapidly in height. The umbilical shoulders are square, the umbilicus narrow and deep, and increases slowly in diameter.

Dimensions.—The specimen, which was septate throughout, gave the following dimensions:

	MM
Diameter	34.0
Height of last whorl from umbilical shoulders	17.5
Breadth	10.0
Width of umbilicus	7.0

This gives the proportions: 1: 0.5: 0.29: 0.20: which agree almost exactly with Karpinsky's figures, 1: 0.5: 0.30: 0.20. On the Arkansas specimen the involution is shown by the height of the last whorl from the top of the next inner one, 12.5 mm. as compared with the total

*C. A. White, *Bull. 77 U. S. Geol. Survey*, p. 21.

height of the whorl which is 17.5 mm. No measurements of this relation were shown on the Russian specimen.

This description applies only to the adult shell, the relative measurements of the nepionic and neanic shells being very different. The Arkansas specimen showed only the last whorl, but the young stages have been worked out by Karpinsky,* from whose work the following description is translated: "Around the cylindrical embryonic chamber (Pl. xxiii, Fig. 8) are coiled very evolute whorls, whose involution increases gradually, but at first only in slight measure (Pl. xxiv, Fig. 8). So, for example, the fourth whorl embraces at the beginning only about one-fourth of the preceding; thus the height of the evolute portion of this fourth whorl is six or seven times as great as that of its own involute portion.

With later stages of growth the involution increases so that the whorls become finally completely embracing, and probably conceal a portion of the umbilicus. Because of this mode of growth the umbilicus appears at first broad, and increasing rapidly, then only gradually, and finally not at all, while the whorl continues to grow in height with great rapidity. Thus, at a diameter of the whorl of four or five millimeters, the umbilicus is about one-half of the total diameter, and at thirty mm. only about one-fifth. The first and second whorls have a broad elliptical cross-section (Pl. xxiv, Fig. 8), while that of the succeeding whorls becomes higher, with the long elliptical axis vertical (Pl. xxiv, Fig. 6), and then finally the flanks are bounded by almost parallel lines and the siphonal side is only slightly arched."

Ontogeny. According to Karpinsky,† the first or typembryonic stage is latisellate, that is the suture consists of a broad abdominal saddle; this saddle is next divided by a broad siphonal lobe (Pl. xxiii. Fig. 7).

The next stage corresponds to the genus *Ibergiceras* Karpinsky, of which *Gon. tetragonus* Roemer, of the Upper Devonian, is the type; in this the whorls are broad, low and only slightly embracing, the umbilicus wide and shallow. The sutures consist of a long rather narrow siphonal lobe, and two broadly rounded lateral lobes. This is the nepionic or larval stage (Pl. xxiv, Fig. 9*a*). In the continuation of this stage the whorls become higher, and the lobes more complicated, corresponding to the genus *Prolecanites*, of which *Gon. henslowi* Phillips and *Gon. serpentinus* Phillips are types.

In the next stage the shape of shell does change materially, but the siphonal lobe becomes three-pointed (Pl. xxiv, Fig. 9*b*); this is the neanic or youthful stage, and corresponds to the genus *Paraprolecanites* Karpinsky, of which the type is *Gon. mixolobus* Sandberger (not Phillips) (*Verstein, Rhein. Schichten-System in Nassau*, p. 67, Pl. iii, Fig. 13?; Pl. ix, Fig. 6).

The further development consists in the division of the first lateral

* *Ammoneen der Artinsk-Stufe*, p. 8.

† *Op. cit.*, p. 4 *et seq.*

lobe by a secondary saddle; the shell is then in the ephebic or adult stage, and in *Pronorites* gets no higher in its development.

The sutures are then constant in shape, and consist of a three-pointed siphonal lobe, a first lateral lobe deeply divided by a secondary saddle and five secondary lateral lobes outside the umbilical border, and one on the umbilical shoulder. All the lobes are pointed, and the saddles rounded. The inner lobes, covered by the involution, are unknown.

The sutures, as figured on Pl. xxiv, Fig. 4, show some differences from those figured by Phillips, Pl. xxiii, Fig. 9, and by Karpinsky,* Pl. xxiv, Fig. 9*f*. On the Arkansas specimen the three-pointed siphonal lobe is longer than on the type of Phillips, or the variety *P. cyclolobus*, variety *uralensis* Karpinsky, the secondary sinus on the first lateral lobe is deeper, and the second lateral lobe is proportionally longer. In this the Arkansas specimen does not depart further from the type than the variety *uralensis*. But if this difference should be thought to be of sufficient importance to characterize a new variety, the name *P. cyclolobus* Phillips, variety *arkansiensis* is proposed.

Surface Markings.—The shell is smooth and devoid of constrictions or other ornamentation, but on the body chamber of the adult, Karpinsky† observed weak ribs, that are stronger on the abdomen and grow weaker towards the umbilicus.

Affinities.—This species is certainly a variety of *Pronorites cyclolobus* Phillips (*Geol. Yorkshire*, Vol. ii, p. 237, Pl. xx, Figs. 40–42), but is more involute at the corresponding diameter, and has a narrower umbilicus and a greater number of lateral lobes. Specimens described by De Koninck‡ from Belgium, and by Roemer§ from the Hartz mountains in Germany, agree perfectly with the type of *Pronorites cyclolobus*; the English, Belgian and German beds, in which the species was found, are all older than the Lower Coal Measure horizon in Arkansas in which it was found, and considerably older than the Upper Carboniferous limestone, in which it was found in the Ural mountains From this Karpinsky‖ thinks the variety *uralensis* represents a mutation from the type of the species.

The form from the Pyrenees described by Barrois¶ as *Pronorites cyclolobus* Phillips has been shown by Karpinsky** to be a new species, *P. barroisi* Karpinsky. This form is more evolute than even the type of *P. cyclolobus*, and its lobes and saddles are broader and also less numerous.

Occurrence.—*Pronorites cyclolobus* Phillips, variety *arkansiensis* J. P. Smith, was found with *Gastrioceras branneri*, sp., nov. J. P. Smith, in

* *Ammoneen der Artinsk-Stufe*, Pl. I, Fig. 4 l.
† *Op. cit.*, p. 9, Pl. I, Fig. 4 *c* and *d*.
‡ *Faune du Calc. Carbon Belgique*, Vol. ii, p. 121, Pl. 1, Figs. 5 and 6.
§ *Palæontographica*, Vol. ix, p. 167, Pl. xxvii, Fig. 1.
‖ *Ammoneen d. Artinsk-Stufe*, p. 10.
¶ *Recherches s. l. terr. anc. d'Asturies et de la Galice*, 1882, p. 295, Pl. xiv, Fig. 2.
** *Loc. cit.*

Arkansas, on Pilot mountain, Carroll county, three and a half miles southwest of Valley Springs, in 17 N., 19 W., section 18, northeast corner, in the Lower Coal Measures, so-called "Millstone Grit." The beds are called A 10 in Prof H. S. Williams' section; below them lie fifty-five feet of micaceous sandstones and shales (A 9 of the section), and below that coarse, reddish-brown fossiliferous limestone, supposed to represent the Chester horizon of the Lower Carboniferous.

The type figured on Pl. xxiv, Figs. 1–4, is the property of the United States Geological Survey (National Museum), catalogue number Sta. 1275. The writer is indebted to Prof. H. S. Williams for the use of the type.

Other Localities.—*Pronorites cyclolobus* has been found in England in the upper part of the Mountain limestone; in Belgium in the limestone of Visé; in the Kohlenkalk of the Hartz, in Germany, and the variety *uralensis* has been found in Russia in the Upper Carboniferous limestone of the Ural mountains in C 2 of the section.

Pronorites, sp. indet., Pl. xx, Fig. 2.

In the Upper Coal Measures beds of Scott county, Arkansas, 1 N., 28 W., section 4, southeast quarter of southeast quarter, was found a single fragment that seems to belong to this genus. It is septate, and must have belonged to an individual about two and a half inches in diameter. The sides are smooth and little embracing and almost parallel; the coil is thin and discoidal, and the ventral or external portion seems to be only slightly arched. From the umbilicus towards the ventral portion are seen five lateral lobes that are long and pointed, the saddles being somewhat rounded. The siphonal lobe and part of the first lateral lobe are not seen, that part of the shell being worn so that they cannot be made out, but enough of the first lateral lobe is visible to show the secondary saddle that divides it. The septa are very close together, as seems to be the case on all species of this genus.

The nearest known relative is *Pronorites cyclolobus* Phillips, var. *uralensis* Karpinsky, *Die Ammoneen der Artinsk-Stufe*, p. 8, Pl. i, Fig. 4. The lobes figured on Pl. i, Fig. 4, of Karpinsky's monograph are very like those of the specimen from Scott county, and the general shape of the coil, the height and the amount of the involution are about the same on both.

Class *Crustacea*.

Order *Trilobitæ*.

Genus PHILLIPSIA, Portlock. *Phillipsia cliftonensis* Shumard, Pl. xxii, Fig. 5. *Phillipsia cliftonensis* Shumard, *Trans. St. L. Ac. Sci.*, Vol. i, p. 226. Compare *Phillipsia scitula* Meek and Worthen, F. B. Meek, *U. S. Geol. Surv. Nebraska*, p. 238, Pl. vi, Fig. 9.

A single well-preserved pygidium seems to belong to Shumard's

species. It is longer than wide, semi-elliptical. The axis is very prominent, has from thirteen to fourteen segments, and the furrows on each side are deep. The segments on the lateral lobes are sharply defined and are eight in number; Shumard mentions only seven on his specimen, but that slight difference is no obstacle to identity of species, since the number varies with age. These lateral segments do not reach the border, but terminate in a lateral furrow which surrounds the pygidium. The species is closely related to *P. scitula* Meek and Worthen, but that species has only eleven axis segments and seven on the sides. Meek was of the opinion that the specimen described as *P. scitula* in *U. S. Geol. Surv. Nebraska*, p. 238, might very possibly belong to *P. cliftonensis*, but Shumard had seen only a pygidium and had no means of characterizing the rest of the body.

Phillipsia major Shumard, figured by Meek in *U. S. Geol. Surv. Nebraska*, Pl iii, Fig. 2, grows much larger than our specimen, and has twenty-two to twenty-three segments on the axis and twelve to thirteen on the sides. These end abruptly at the lateral furrow, which is much wider than that on *P. cliftonensis*.

Occurrence and Locality.—A single well-preserved pygidium was found in the Upper Coal Measures of Poteau mountain, Indian Territory, associated with a fauna similar to that of the Upper Coal Measures or Permo-Carboniferous of Nebraska.

Phillipsia (*Griffithides*) *scitula* Meek and Worthen, *Proc. Ac Sci. Phila.*, 1865, p. 270, and *Paleont. Ill.*, Vol. v, p. 612, Pl. xxxii, Fig. 3.

A pygidium from the Lower Coal Measures of White county, Arkansas, 9 N., 4 W., section 6, and another from similar strata in 9 N., 5 W., section 1, show the characteristics of this species, but are too imperfect to figure

Phillipsia, sp.

In the Lower Coal Measures of Johnson county, Arkansas, 11 N., 24 W., section 26, southeast quarter of southwest quarter, was found a pygidium of Phillipsia that could not be identified with certainty, although it probably belongs to one of the known species.

Phillipsia (*Griffithides*) *ornata* A.W.Vogdes, Pl. xxii, Fig. 6. *Griffithides ornata* A. W. Vogdes, *Proc. Cal. Acad. Sci.*, Ser. ii, Vol. iv, p. 589, "Notes on Palæozoic Crustacea, No. 4. On a New Trilobite from Arkansas Lower Coal Measures," by A. W. Vogdes.

The following description is copied from an advance sheet kindly furnished by Capt. Vogdes:

"The only specimen of this new species was discovered in Conway county, Arkansas, and consists of a head shield which is unfortunately not quite perfect, only exhibiting the right side and part of the glabella, with portions of the thorax and an entire pygidium; but it shows sufficient new characters to authorize us in considering it as a new species.

"The head shows that the latero-posterior angles are produced into short spines extending to about the third segment of the thorax, the glabella is pyriform, gibbous in front, and destitute of lateral furrows; basal lobes prominent The posterior border of the glabella has two small, round nodes. The cervical lobe is broad and well marked, much broader than the axial lobes.

"The thorax exhibits imperfectly parts of the pleuræ and also the axis. Thorax with nine segments. The axis shows a series of nodes running through the centre of each ring. The pleuræ are smooth, each pleural groove extending slightly beyond the fulcral point; the extremities are probably rounded, but this is not indicated by the imperfect specimen now before us.

"The pygidium exhibits both in the axis and lateral lobes distinct segmentation. The axis does not extend to the posterior margin. The entire pygidium is surrounded by a marginal border, which widens out slightly anteriorly.

"The tail is parabolic in form, very convex and not as broad as the head, measuring on its anterior border 12 mm. The axis is broad, conical and prominent, occupying a little less than one-third the width of the tail on the anterior margin. It is marked with eleven rings; these become smaller and smaller and end in an obtuse point. Each ring is distinctly ornamented along the centre by a series of nodes, arranged into three double rows of two each. The sides of the axis are smooth.

"The lateral lobes are slightly flattened on top to the fulcral point. They are marked with seven pleuræ; the grooves between the pleuræ are deep and distinct, each being rounded on top and ornamented with a single node at the fulcral point; here they bend suddenly and join the marginal border.

"*Locality and Position.*—Lower Coal Measures, T. 5 N., R. 16 W., section 17, near centre of northwest quarter of the section, Conway county, Arkansas. From the collection of the Geological Survey of Arkansas.

"*Affinities and Differences.*—This species in some of its features resembles *Phillipsia rœmeri* Möller (*Ueber die Trilobiten Steinkohlenformation des Ural*, Pl. ii, Fig. 17), especially in the markings of the tail, which shows seven pleuræ ornamented by a single node at the fulcral joint, but it differs in form and especially in the marking of the axial lobe, so much so that it could not be placed under Möller's species. There is also a resemblance of this species with *Phillipsia* (*Griffithides*) *scitula* Meek and Worthen, from the Illinois Coal Measures. It has the same number of rings in the axis of the tail, and the same characteristic pleuræ and ornamentation, but the Arkansas species differs greatly in size and also in the number of pleuræ, seven instead of six. The axis is not as wide as in *Griffithides scitula* and not distinctly flattened on each side. The limb, although moderately wide and smooth, is not depressed or nearly flat, but convex. Secondly, the ornamentation of

the axis is entirely different, so much so that it would not warrant its reference to the Illinois species.

"It is doubtful in our present state of knowledge whether *Phillipsia* (*Griffithides*) *scitula* M. and W. should not be referred to the older name of *Phillipsia cliftonensis* Shumard, from the Upper Coal Measures, Clifton Park, Kansas, described from a pygidium. Dr. Shumard says that the axis has from thirteen to fourteen subgranulose rings and seven side segments. A thorough study of all these allied species may necessitate their reference to the older name; but for the present it would be advisable to give the Arkansas species a new name on account of the ornamentation of its tail."

Class *Arachnoidea.*

Order *Xiphosura.*

Genus undetermined. PRESTWICHIA?

In the Lower Coal Measures of White county, Arkansas, 9 N., 4 W., section 6, was found the mould of a part of the body of a crustacean that seems to belong to the family of the *Hemiaspidæ*, and yet differs from all known genera of this family in being armed with two rows of spines instead of only one.

Too little of the body is known for a generic description.

	Fauna of the Coal Measures of Arkansas.	Lower Carboniferous.	Lower Coal Measures.	Upper Coal Measures.	Locality in Arkansas.	Other Localities.	
	BRYOZOA.						
1	*Fenestella shumardi* Prout.	X		X	Poteau mountain, Indian Territory; Stone county, Arkansas, in Boone chert, 15 N., 12 W., Sec. 27.	Lower Coal Measures, Ohio; Upper Coal Measures, Nebraska.	
2	*Rhombopora lepidendroides* Meek.			X	Poteau mountain, Indian Territory.	Upper Coal Measures, Nebraska, China.	
3	*Septopora biserialis* Swallow.			X	Poteau mountain, Indian Territory.	Permo-Carboniferous, Kansas and Nebraska; Upper Coal Measures, Nebraska; Upper and Lower Coal Measures and Lower Carboniferous, Illinois; Upper Carboniferous, Arizona.	3
	ANTHOZOA.						
4	*Fistulipora nodulifera* Meek.			X	Sebastian county, 8 N. 32 W., Sec. 12: Poteau mountain, Indian Territory.	Upper Coal Measures, Nebraska, Iowa, Illinois.	4
5	*Lophophyllum proliferum* McChesney.			X	Poteau mountain, Indian Territory.	Coal Measures, Nebraska, Texas, Illinois, China, etc.	
6	*Zaphrentis*, sp.			X	Crawford county, 10 N., 30 W., Sec. 10.		
7	*Zaphrentis*, sp.		X		Conway county, 5 N., 16 W., Sec. 17.		
	ECHINODERMATA.						
8	*Cyathocrinus*, sp.			X	Scott county, 1 N., 28 W., Sec. 4.		8
9	*Erisocrinus* (*Ceriocrinus*) *inflexus* Geinitz.			X	Poteau mountain, Indian Territory.	Coal Measures, Utah, Nebraska, etc.	9
10	*Hydreinocrinus mucrospinosus* McChesney.			X	Poteau mountain, Indian Territory.	Coal Measures, Mississippi valley.	10

	Fauna of the Coal Measures of Arkansas.	Lower Carboniferous.	Lower Coal Measures.	Upper Coal Measures.	Locality in Arkansas.	Other Localities.	
	ECHINODERMATA—Continued.						
11	*Poteriocrinus*, sp.			X	Poteau mountain, Indian Territory.		11
12	Crinoid stems, genus (?).		X		Pope county, 10 N., 20 W., Sec. 8.		12
13	Crinoid stems, genus (?).		X		White county, 8 N., 7 W., Secs. 33 and 26.		13
	BRACHIOPODA.						
14	*Athyris subtilita* Hall.	X	X	X	Sebastian county, 8 N., 32 W., Sec. 12; Poteau mountain, Indian Territory; Conway county, 6 N., 16 W., Sec. 29; in Boone chert, Stone county, 14 N., 10 W., Sec. 9.	Permo-Carboniferous of Kansas and Nebraska; world-wide in Coal Measures and Lower Carboniferous.	14
15	*Orthis* conf. *resupinoides* Cox.		X		White county, 8. N., 7 W., Sec. 33; Conway county, 8 N., 17 W., Sec. 33.	Coal Measures, Kentucky; Upper Carboniferous, New Mexico.	15
16	*Orthis pecosii* Marcou.	?	X	X	Poteau mountain, Indian Territory; Conway county, 6 N., 16 W., Sec. 29, southwest quarter of southwest quarter; Boone chert, Stone county, 14 N., 10 W., Sec. 9 (?).	Upper Coal Measures, Mississippi valley; New Mexico, China, India; Lower Carboniferous in California (?).	16
17	*Productus cora* d'Orbigny.	X		X	Poteau mountain, Indian Territory; Lower Carboniferous, Washington, Crawford, Independence and Stone counties.	Salt Range, India; China; South America; Upper Coal Measures and Permo-Carboniferous.	17
18	*Productus splendens* Norwood and Pratten.			X	Poteau mountain, Indian Territory.	Coal Measures and Permian, Mississippi valley region.	18
19	*Productus punctatus* Martin.	X	X		Conway county, 6 N., 16 W., Sec. 29.	Universal in Upper and Lower Carboniferous.	19

	Fauna of the Coal Measures of Arkansas.	Lower Carboniferous.	Lower Coal Measures.	Upper Coal Measures.	Locality in Arkansas.	Other Localities.	
	BRACHIOPODA—Continued.						
20	*Productus semireticulatus* Martin.	X	X		White county, 8 N., 7 W., Secs. 33 and 26; Lower Carboniferous in Independence and Searcy counties.	Universal in Upper and Lower Carboniferous.	20
21	*Retzia radialis* Phillips.			X	Sebastian county, 8 N., 32 W., Sec. 12; and Poteau mountain, Indian Territory.	Coal Measures, Nebraska, Kansas, New Mexico, Nevada, etc.	21
22	*Rhynchonella uta* Marcou.			X	Sebastian county, 8 N., 32 W., Sec. 12; and Poteau mountain, Indian Territory.	Coal Measures, universal in the West.	22
23	*Rhynchonella*, sp.			X	Crawford county, 10 N., 32 W., Sec. 10.		23
24	*Rhynchonella*, sp.		X		White county, 8 N., 7 W., Sec. 33.		24
25	*Spirifer cameratus* Morton.		X		Sebastian county, 8 N., 32 W., Sec. 12; Poteau mountain, Indian Territory; Conway county, 6 N., 16 W., Sec. 29.	Coal Measures, universal in the West.	25
26	*Spirifer rockymontanus* Marcou.		X	X	White county, 8 N., 7 W., Sec. 33.	Coal Measures, Pennsylvania to Rocky mountains.	26
27	*Spiriferina cristata* Schlotheim.	?	X	X	Sebastian county, 8 N., 32 W., Sec. 12; Poteau mountain, Indian Territory; Conway county, 6 N., 16 W., Sec. 29; Lower, Carboniferous, Marble City, Newton county.	Universal in Western Coal Measures, chiefly Upper Coal Measures.	27
28	*Derbyia crassa* Meek and Hayden.	X	X	X	Conway county, 6 N., 16 W., Sec. 29; Poteau mountain, Indian Territory.	Universal in Western Coal Measures.	28
29	*Terebratula hastata* Sowerby.		X	X	Poteau mountain, Indian Territory; Conway county, 8 N., 17 W., Sec. 33; north-east quarter of northeast quarter.	Universal in Western Coal Measures.	29

	Fauna of the Coal Measures of Arkansas.	Lower Carboniferous.	Lower Coal Measures.	Upper Coal Measures.	Locality in Arkansas.	Other Localities.	
	LAMELLIBRANCHIATA.						
30	*Astartella newberryi* Meek.		X	X	Sebastian county, 8 N., 32 W., Sec. 12; Conway county, 8 N., 17 W., Sec 33; Poteau mountain, Indian Territory.	Coal Measures, Ohio.	30
31	*Astartella vera* Hall.			X	Poteau mountain, Indian Territory.	Coal Measures, Illinois, Pennsylvania, etc.	31
32	*Aviculopecten carboniferus* Stevens.		X		White county, 8 N., 7 W., Sec. 26; Conway county, 5 N., 16 W., Sec. 17.	Coal Measures, Indiana, etc.	32
33	*Aviculopecten coxanus* Meek & Worthen			X	Poteau mountain, Indian Territory.	Coal Measures, Nebraska and Illinois.	33
34	*Aviculopecten germanus* Miller & Faber			X	Poteau mountain, Indian Territory.	Coal Measures, Kentucky.	34
35	*Aviculopecten* conf. *occidentalis* Shumard.		X		Conway county, 5 N., 16 W., Sec. 17; 6 N., 16 W., Sec. 29.	Coal Measures from Pennsylvania to Arizona.	35
36	*Conocardium* conf. *aliforme* Sowerby.		X		Conway county, 5 N., 16 W., Sec. 17.	Carboniferous, probably Upper, of England, Belgium, Germany and Russia.	36
37	*Edmondia nebrascensis* Geinitz, sp.			X	Poteau mountain, Indian Territory.	Coal Measures, Nebraska.	37
38	*Edmondia unioniformis* Phillips.		X		Conway county, 8 N., 17 W., Sec. 33.	Coal Measures, Illinois, England.	38
39	*Lima retifera* Shumard.			X	Poteau mountain, Indian Territory.	Coal Measures, Kansas, Nebraska, Texas.	39
40	*Macrodon carbonarius* Cox.		X	X	Conway county, 5 N., 16 W., Sec. 17; Poteau mountain, Indian Territory.	Coal Measures, Mississippi valley, China.	40

	Fauna of the Coal Measures of Arkansas.	Lower Carboniferous.	Lower Coal Measures.	Upper Coal Measures.	Locality in Arkansas.	Other Localities.	
	LAMELLIBRANCHIATA—Contin'd.						
41	*Macrodon obsoletus* Meek.			X	Sebastian county, 8 N., 32 W., Sec. 12; Poteau mountain, Indian Territory.	Coal Measures, West Virginia and Ohio.	41
42	*Macrodon tenuistriatus* Meek and Worthen.	X		X	Poteau mountain, Indian Territory; Moorefield, Independence county.	Upper Coal Measures, Nebraska.	42
43	*Macrodon*, sp.			X	Crawford county, 10 N., 30 W., Sec. 10.		43
44	*Nuculana* aff. *bellistriata* Stevens.			X	Scott county, 1 N., 28 W., Sec. 4.	Coal Measures, Mississippi valley.	44
45	*Nucula parva* McChesney.		X	X	Conway county, 5 N., 16 W., Sec. 17; Sebastian county, 8 N., 32 W., Sec. 12; Crawford county, 10 N., 30 W., Sec. 10.	Coal Measures, Illinois, etc.	45
46	*Nucula ventricosa* Hall.		X		Conway county, 5 N., 16 W., Sec. 17.	Coal Measures, Iowa, Pennsylvania, Texas, etc.	46
47	*Pleurophorus oblongus* Meek.		X		Conway county, 5 N., 16 W., Sec. 17.	Upper Coal Measures, Nebraska.	47
48	*Pleurophorus*, sp.			X	Scott county, 1 N., 28 W., Sec. 4.	Permian, Texas.	48
49	*Schizodus* conf. *amplus* Meek and Worthen.		X		White county, 8 N., 7 W., Sec. 33.	Coal Measures, Illinois, etc.	49
50	*Schizodus wheeleri* Swallow.		X		Conway county, 8 N., 17 W., Sec. 33.	Coal Measures of the Mississippi valley region.	50
5	*Schizodus cuneatus* Meek.		X	X	Crawford county, 10 N., 30 W., Sec. 10; Conway county, 8 N., 17 W., Sec. 33.	Lower Coal Measures, Ohio; Upper Coal Measures, Nebraska (?).	51

	Fauna of the Coal Measures of Arkansas.	Lower Carboniferous.	Lower Coal Measures.	Upper Coal Measures.	Locality in Arkansas.	Other Localities.	
	GASTEROPODA.						
52	*Bellerophon carbonarius* Cox.		X		Conway county, 5 N., 16 W., Sec. 17, and 8 N., 17 W., Sec. 33; Franklin county, 10 N., 26 W., Sec. 2.	Coal Measures, Mississippi valley.	52
53	*Bellerophon crassus* Meek & Worthen.		X		Conway county, 5 N., 16 W., Sec. 17.	Coal Measures, Pennsylvania and Western States; also Lower Carboniferous, Pennsylvania.	53
54	*Bellerophon marcoudnus* Geinitz.			X	Sebastian county, 8 N., 32 W., Sec. 12.	Coal Measures, Mississippi valley.	54
55	*Bellerophon*, sp.		X		White county, 8 N., 7 W., Secs. 33 and 26.		55
56	*Euomphalus subquadratus* Meek and Worthen.		X		White county, 9 N., 5 W., Sec. 1, and 9 N., 4 W., Sec. 6.	Coal Measures, Illinois.	56
57	*Euomphalus*, sp.		X		Independence county, 11 N., 5 W., Sec. 9.		57
58	*Dentalium* conf. *meekianum* Geinitz.			X	Crawford county, 10 N., 30 W., Sec. 10.	Permo-Carboniferous, Nebraska.	58
59	*Macrocheilus* conf. *fusiformis* Hall.		X		Conway county, 5 N., 16 W., Sec. 17.	Coal Measures, Iowa.	59
60	*Macrocheilus* conf. *primigenius* Conrad		X		Conway county, 5 N., 16 W., Sec. 17.	Coal Measures, Iowa, Indiana, Ohio, Illinois.	60
61	*Naticopsis nana* Meek and Worthen.			X	Sebastian county, 8 N., 32 W., Sec. 12.	Coal Measures from Illinois to Nevada.	61
62	*Naticopsis*, sp.			X	Scott county, 1 N., 28 W., Sec. 4.	Texas Permian (?).	62
63	*Pleurotomaria modesta* Keyes.			X	Crawford county, 10 N., 30 W., Sec. 10.	Coal Measures, Kentucky and Pennsylvania.	63

	Fauna of the Coal Measures of Arkansas.	Lower Carboniferous.	Lower Coal Measures.	Upper Coal Measures.	Locality in Arkansas.	Other Localities.	
	GASTEROPODA—Continued.						
64	*Pleurotomaria* conf. *speciosa* Meek and Worthen.			X	Poteau mountain, Indian Territory.	Coal Measures, Illinois.	64
65	*Pleurotomaria tenuicincta* Meek and Worthen.			X	Poteau mountain, Indian Territory.	Upper Coal Measures, Illinois.	65
66	*Pleurotomaria harii* S. A. Miller.		X		Conway county, 8 N., 17 W., Sec. 33.	Upper Coal Measures, Missouri.	66
67	*Pleurotomaria*, sp.		X		Conway county, 5 N., 16 W., Sec. 17.		67
68	*Pleurotomaria*, sp.		X		Pope county, 10 N., 20 W., Sec. 8.		68
69	*Pleurotomaria*, sp.		X		Franklin county,12 N., 28 W., Sec. 27.		69
70	*Polyphemopsis inornata* Meek and Worthen.			X	Crawford county, 10 N., 30 W., Sec. 10.	Upper Coal Measures, Illinois.	70
	PTEROPODA.						
71	*Conularia* conf. *crustula* White.			X	Scott county, 1 N., 28 W., Sec. 4.	Coal Measures, New Mexico, Missouri.	71
	CEPHALOPODA.						
72	*Goniatites* (*Gastrioceras*), sp. indet.			X	Scott county, 1 N., 28 W., Sec. 4.		72
73	*Goniatites* (*Gastrioceras*) *excelsus* Meek.		X		Pope county, 10 N., 20 W., Sec. 8.	Coal Measures, Kansas.	73
74	*Goniatites* (*Gastrioceras*) *marianus* Verneul.			X	Scott county, 1 N., 28 W., Sec. 4.	Upper Carboniferous Limestone, Ural mountains.	74

	Fauna of the Coal Measures of Arkansas.	Lower Carboniferous.	Lower Coal Measures.	Upper Coal Measures.	Locality in Arkansas.	Other Localities.	
	CEPHALOPODA—Continued.						
75	*Goniatites* (*Gastrioceras*) *globulosus* Meek and Worthen.			X	Scott county, 1 N., 28 W., Sec. 4.	Upper Coal Measures, Illinois.	75
76	*Goniatites* (*Gastrioceras*) *branneri*, n. sp., J. P. Smith.		X		Carroll county, Pilot mountain, 17 N., 19 W., Sec. 18.		76
77	*Goniatites* (*Paralegoceras*) *iowensis* Meek and Worthen.		X		Conway county, 5 N., 16 W., Sec. 17.	Coal Measures, Iowa; Lower Carboniferous, Bend Formation, Texas; Upper Coal Measures, Kansas City, Mo.	77
78	*Goniatites* (*Pronorites*), sp.			X	Scott county, 1 N., 28 W., Sec. 4.	Ural mountains (?).	78
79	*Goniatites* (*Pronorites*) *cyclolobus* Phillips, var. *arkansiensis* J. P. Smith.		X		Carroll county, Pilot mountain, 17 N., 19 W., Sec. 18.	Carboniferous Limestone of England, Belgium, Russia.	79
80	*Nautilus* (*Endolobus*) *missouriensis* Swallow, (?).		X		Conway county, 5 N., 16 W., Sec. 17.	Coal Measures, Indiana, Missouri, Illinois (?).	80
81	*Nautilus* (*Ephippioceras*) *ferratus* Cox.		X		Conway county, 5 N., 16 W., Sec. 17; White county near Searcy.	Coal Measures, Kentucky.	81
82	*Nautilus*, sp.			X	Crawford county, 10 N., 30 W., Sec. 10.		82
83	*Orthoceras cribrosum* Geinitz.			X	Poteau mountain, Indian Territory.	Coal Measures, Nebraska.	83
84	*Orthoceras* conf. *rushense* McChesney.			X	Scott county, 1 N., 28 W., Sec. 4.	Coal Measures and Permian, Texas, etc.	84
85	*Orthoceras*, sp.		X		Conway county, 8 N., 17 W., Sec. 33.		85

	Fauna of the Coal Measures of Arkansas.	Lower Carboniferous.	Lower Coal Measures.	Upper Coal Measures.	Locality in Arkansas.	Other Localities.	
	CRUSTACEA.						
86	*Phillipsia cliftonensis* Shumard.			X	Poteau mountain, Indian Territory.	Upper Coal Measures and Permo-Carboniferous of Kansas.	86
87	*Phillipsia (Griffithides) scitula* Meek and Worthen.		X		White county, 9 N., 4 W., Sec. 6, and 9 N., 5 W., Sec. 1; Conway county, 5 N., 16 W., Sec. 17.	Coal Measures, Illinois and Nebraska.	87
88	*Phillipsia*, sp.		X		Johnson county, 11 N., 24 W., Sec. 26.		88
89	*Phillipsia (Griffithides) ornata* Vogdes.		X		Conway county, 5 N., 16 W., Sec, 17.		89
	Prestwichia (?).		X		White county, 9 N., 4 W., Sec. 6.		90

EXPLANATION OF PLATES.*

Plate XVI

Fig. 1. *Gastrioceras marianum* Verneul 260
  1 *a*. Side view.
  1 *b*. Rear view.
Fig. 2. *G. marianum*, artificial cast, magnified twice.
  2 *a*. Front view.
  2 *b*. Side view.
Fig. 3. *G. marianum*, largest specimen.
  3 *a*. Side view.
  3 *b*. Cross section of whorl.
Fig. 4. *G. marianum*, artificial cast.
Fig. 5. *a, b, c*. *G. marianum*, showing the development of the sutures.

Plate XVII.

Fig. 1. *Gastrioceras excelsum* Meek 260
  1 *a*. Side view.
  1 *b*. Cross section of whorl.
  1 *c*. Sutures.

Plate XVIII.

Fig. 1. *Gastrioceras globulosum* Meek and Worthen 258
  1 *a*. Side view of small specimen.
  1 *b*. Front view of small specimen.
Fig. 2. *G. globulosum*, artificial cast from a mould.
  2 *a*. Side view.
  2 *b*. Front view.
Fig. 3. *G. globulosum*, sutures, enlarged twice.
Fig. 4. *G. globulosum*, cast showing surface markings.
Fig. 5. *G. globulosum*, small globose specimen doubtfully referred to this species.
  5 *a*. Front view.
  5 *b*. Side view.
Fig. 6. *G. globulosum*, small specimen showing the low flattened whorl.
  6 *a*. Side view.
  6 *b*. Front view.

Plate XIX.

Fig. 1. *Paralegoceras iowense* Meek and Worthen 263
  1 *a*. Side view, partly restored.
  1 *b*. Front view.
Fig. 2. *P. iowense*, inner whorl taken out of the large specimen shown in Fig. 1.
  2 *a*. Side view.
  2 *b*. Front view.

*Where not otherwise stated the figures are all natural size.

Fig. 3. *P. iowense*, sutures.

3 *a*. Sutures taken from the inner whorl of 25 millimeters diameter.

3 *b*. Sutures on the outer whorl.

Fig. 4. *Glyphioceras diadema* Goldfuss, showing development of the sutures (after Branco, *Palæontographica*, Vol. xxvii, Pl. ix, Fig. 1).

4 *a*. First suture.

4 *b*. Second suture.

4 *c*. Third suture.

4 *d*. At 1.25 millimetres diameter.

4 *e*. At 2.25 millimetres.

4 *f*. Adult.

Fig. 5. *Tornoceras retrorsum* v. Buch (after Branco).

5 *a*. First suture.

5 *b*. Second suture.

5 *c*. At 1.75 millimetres diameter.

5 *d*. At 2.50 millimetres.

5 *e*. At 10 millimetres, adult.

Plate XX.

Fig. 1. *Gastrioceras*, sp. indet. 262

1 *a*. Side view of a composite artificial cast, from three specimens.

1 *b*. Side view of a septate fragment.

1 *c*. Cross section of whorl.

1 *d*. Sutures.

Fig. 2. *Pronorites*, sp. 270

2 *a*. Side view of septate fragment.

2 *b*. Cross section of whorl.

2 *c*. Sutures.

Plate XXI.

Fig. 1. *Endolobus missouriensis* Swallow 252

1. Side view of large specimen.

Fig. 2. *Endolobus missouriensis* Swallow.

2 *a*. Side view of small specimen.

2 *b*. Rear view of small specimen.

2 *c*. Front view of small specimen, twice enlarged

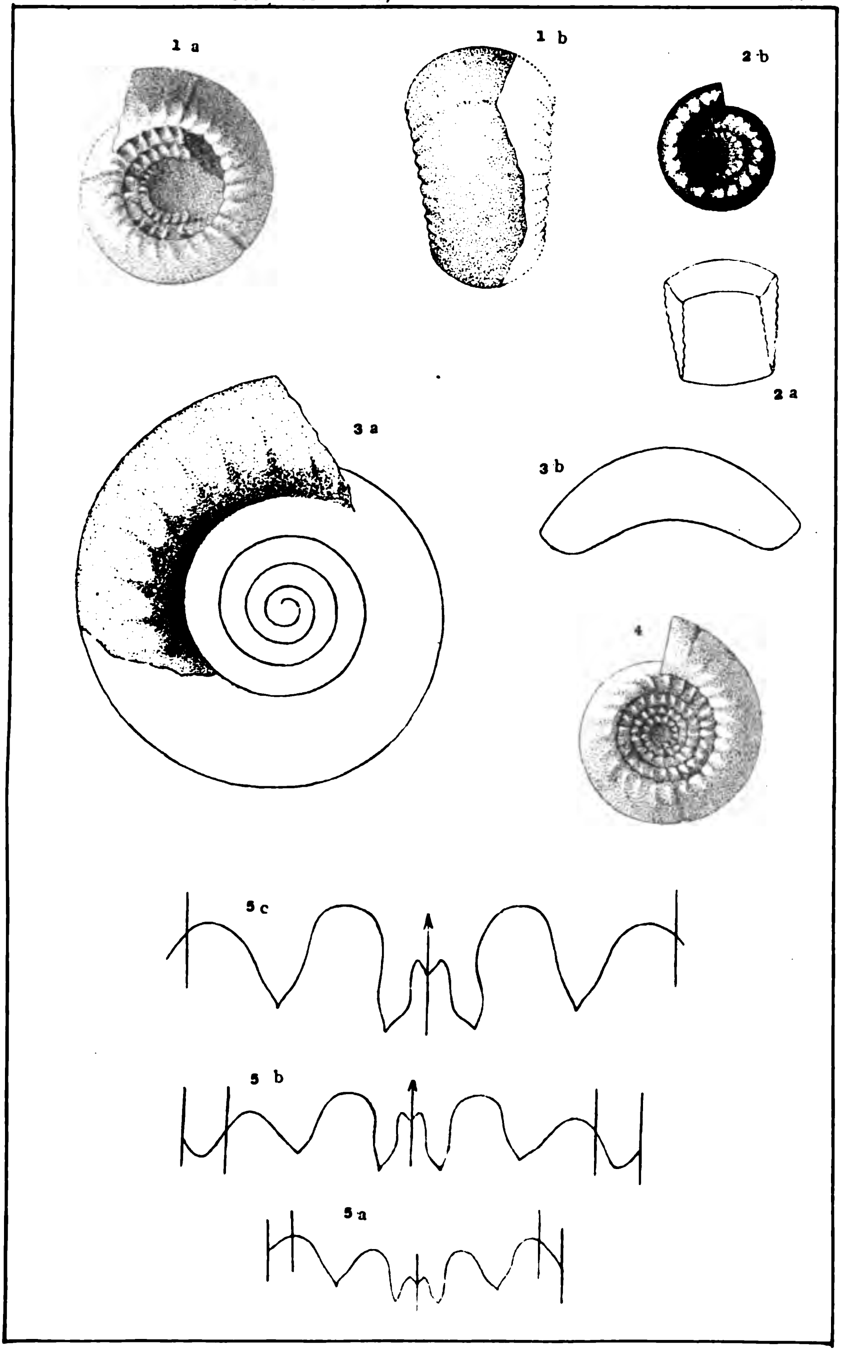
Fig. 3. *Endolobus missouriensis* Swallow.

3 *a*. Dorsal view, showing internal lobe.

3 *b*. Concave side of chamber.

3 *c*. Convex side of chamber.

3 *d*. Chamber, from the side.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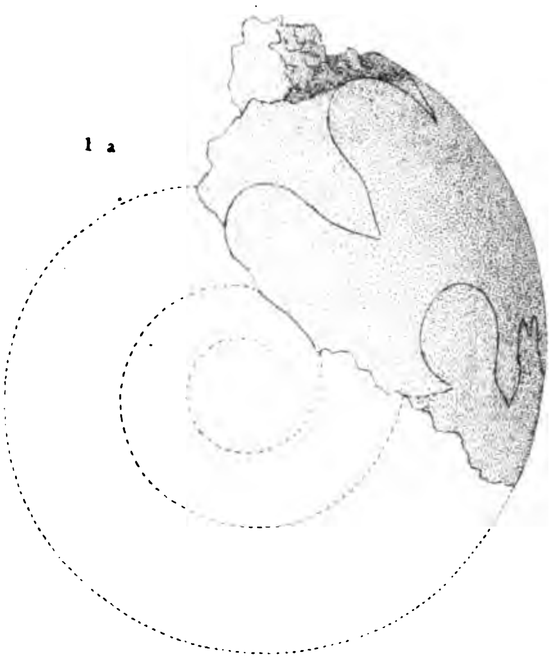

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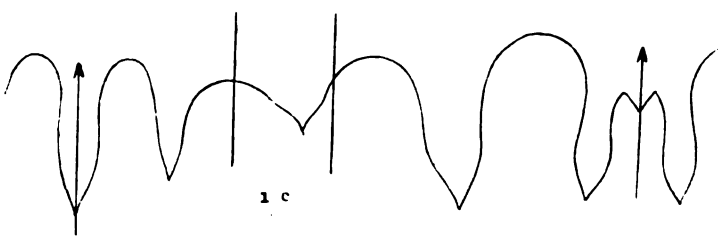

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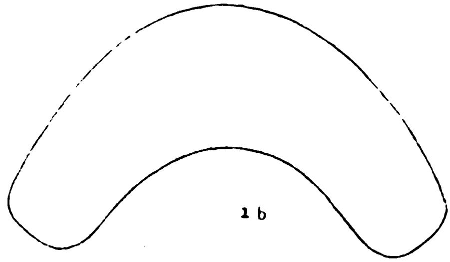

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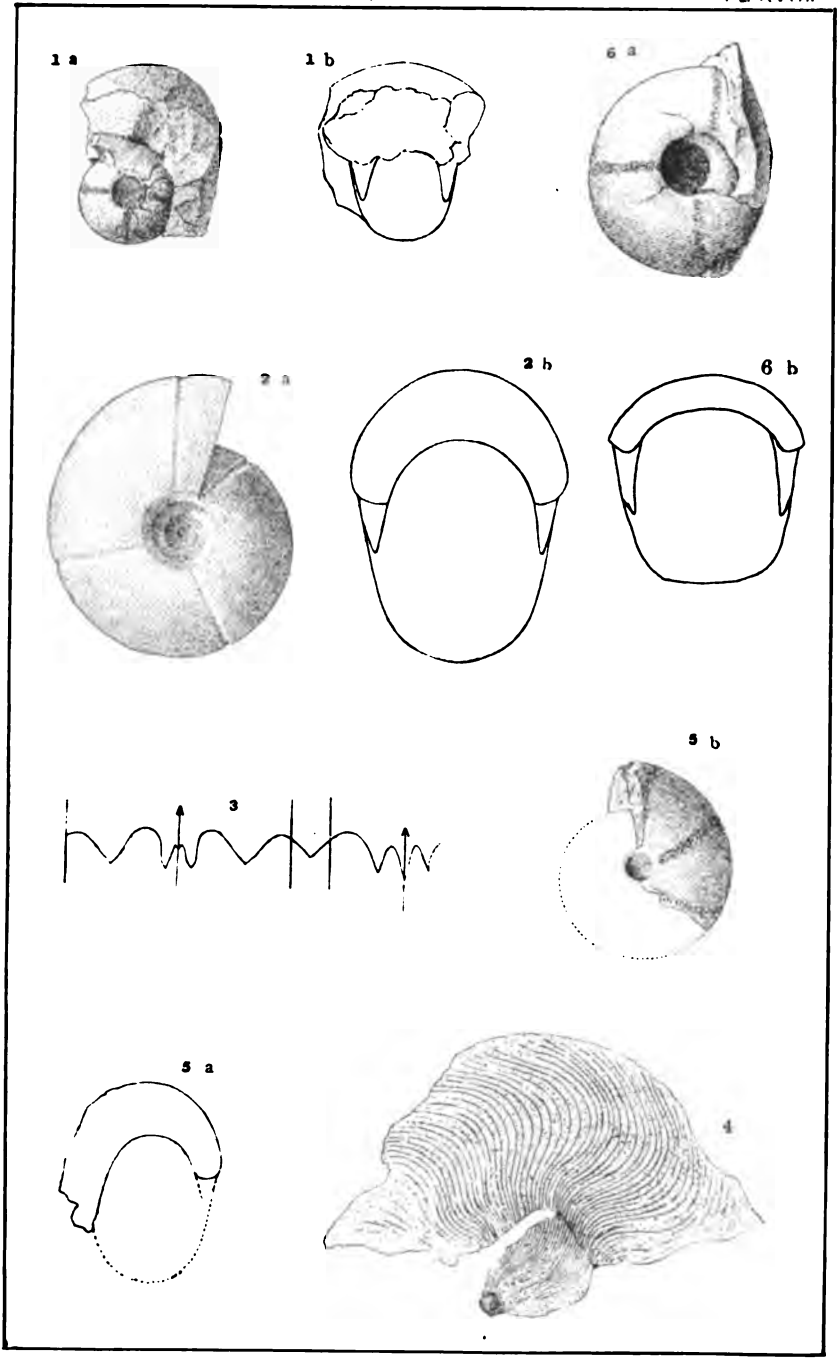
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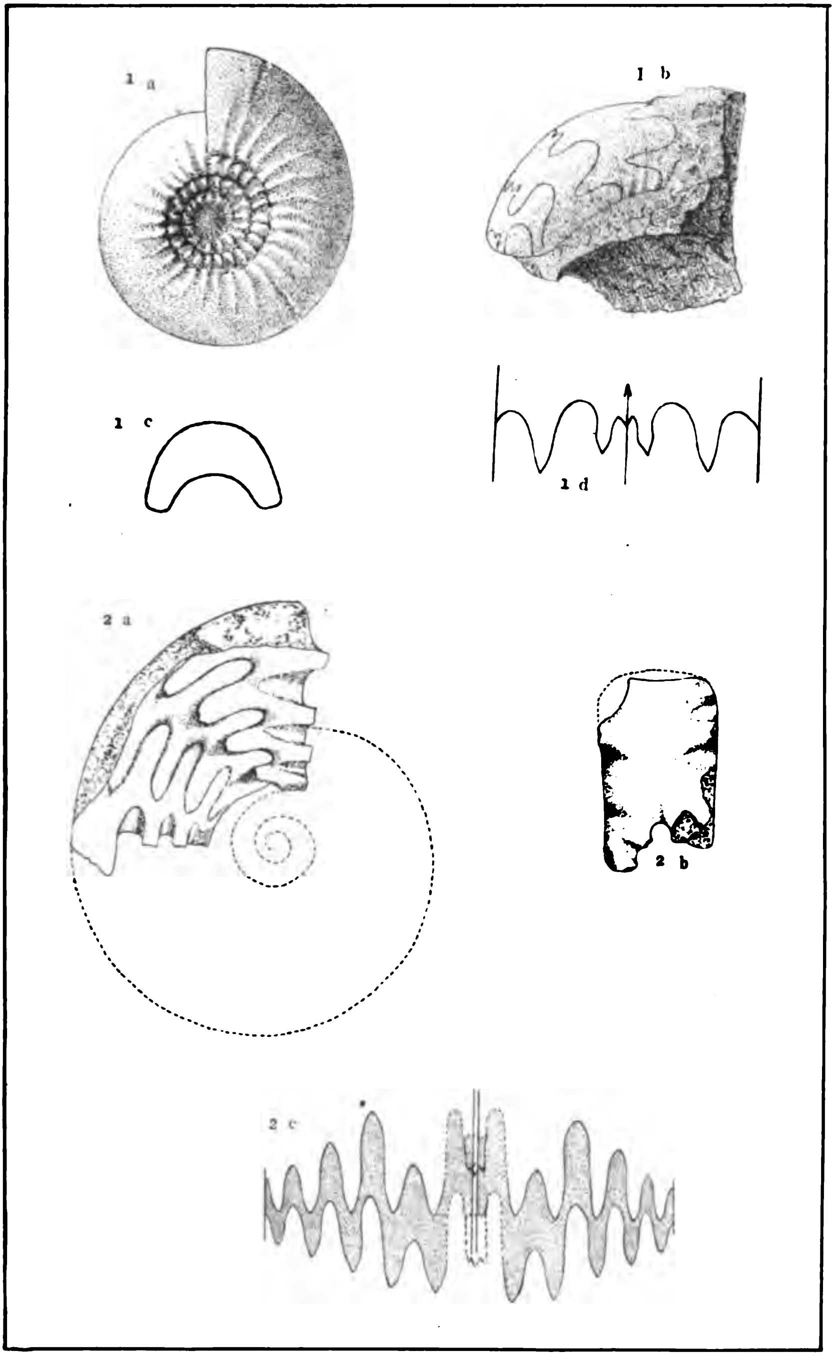
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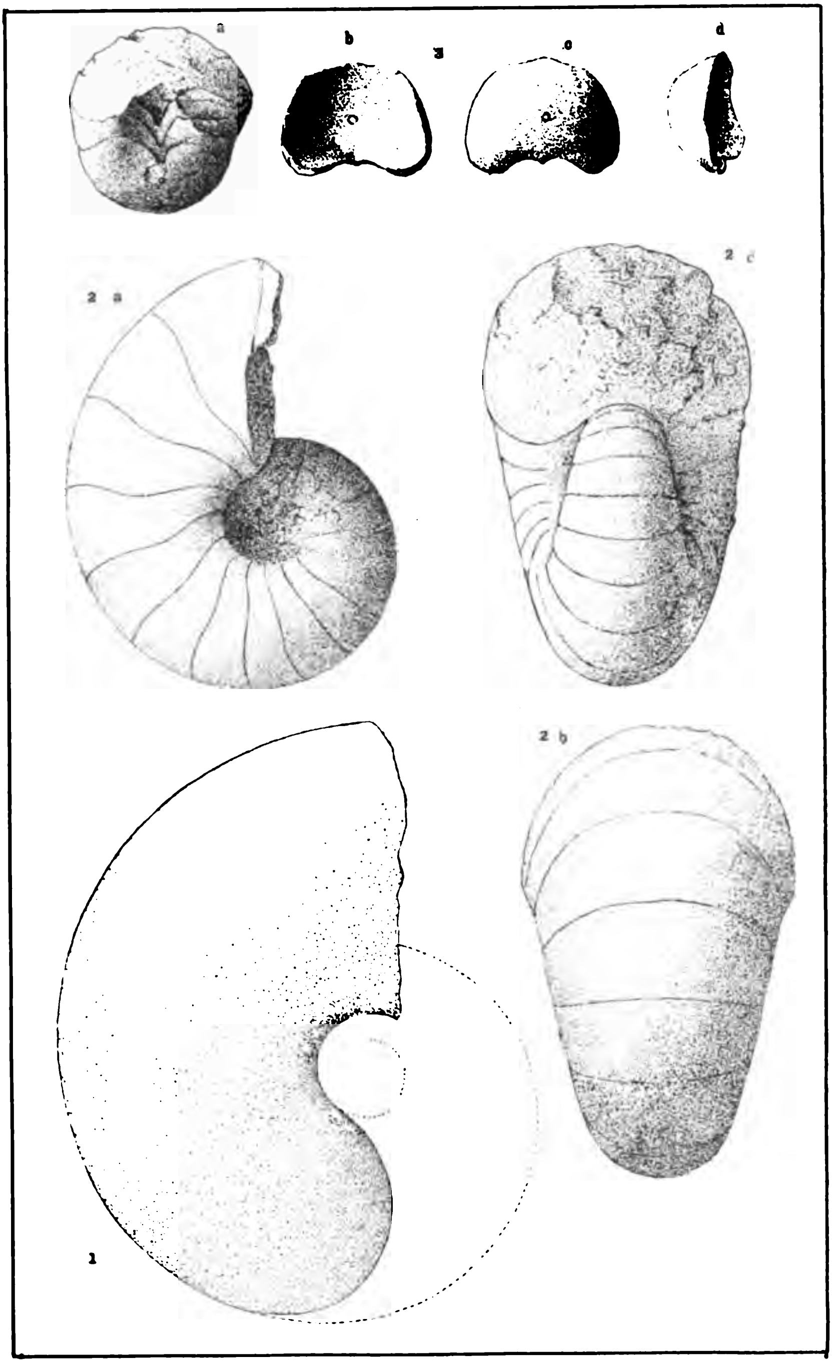
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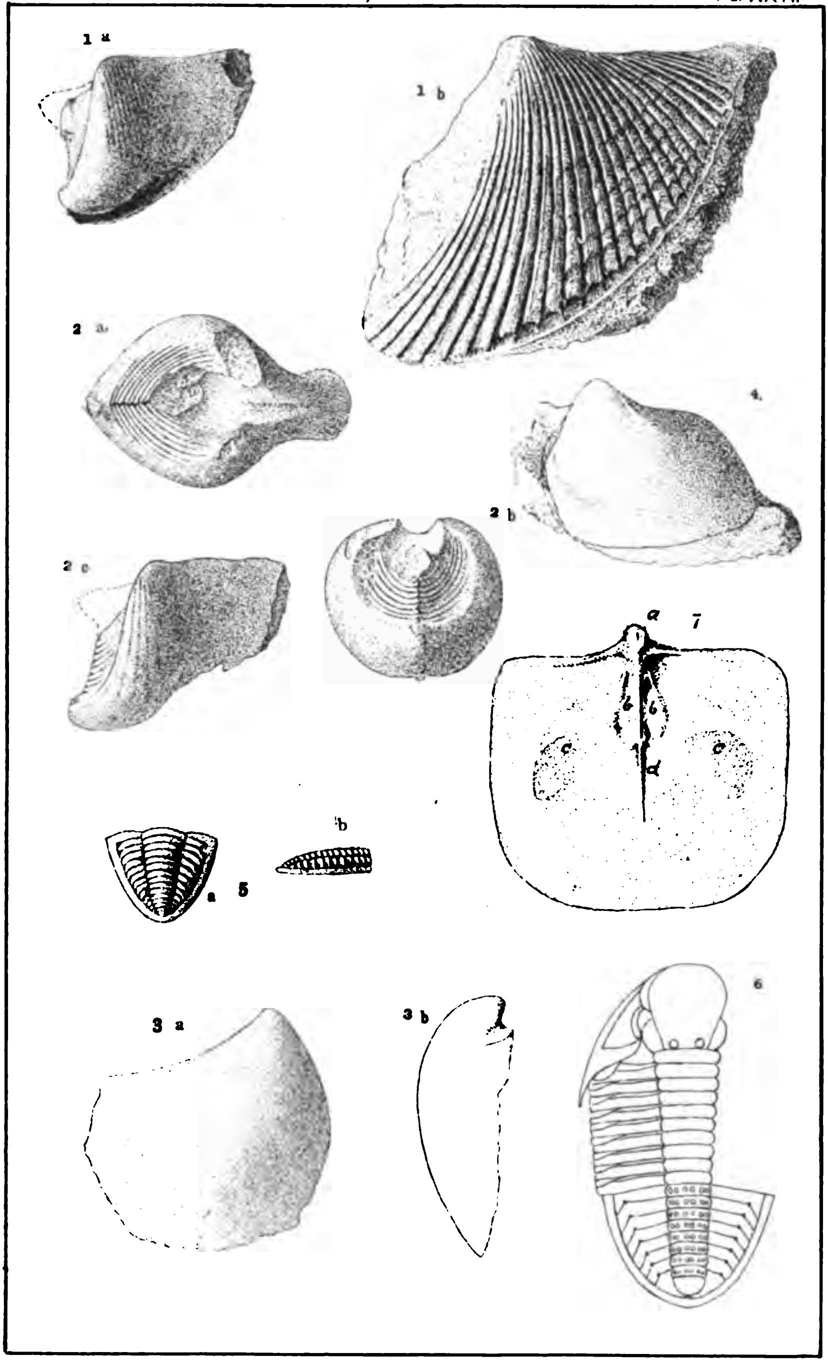
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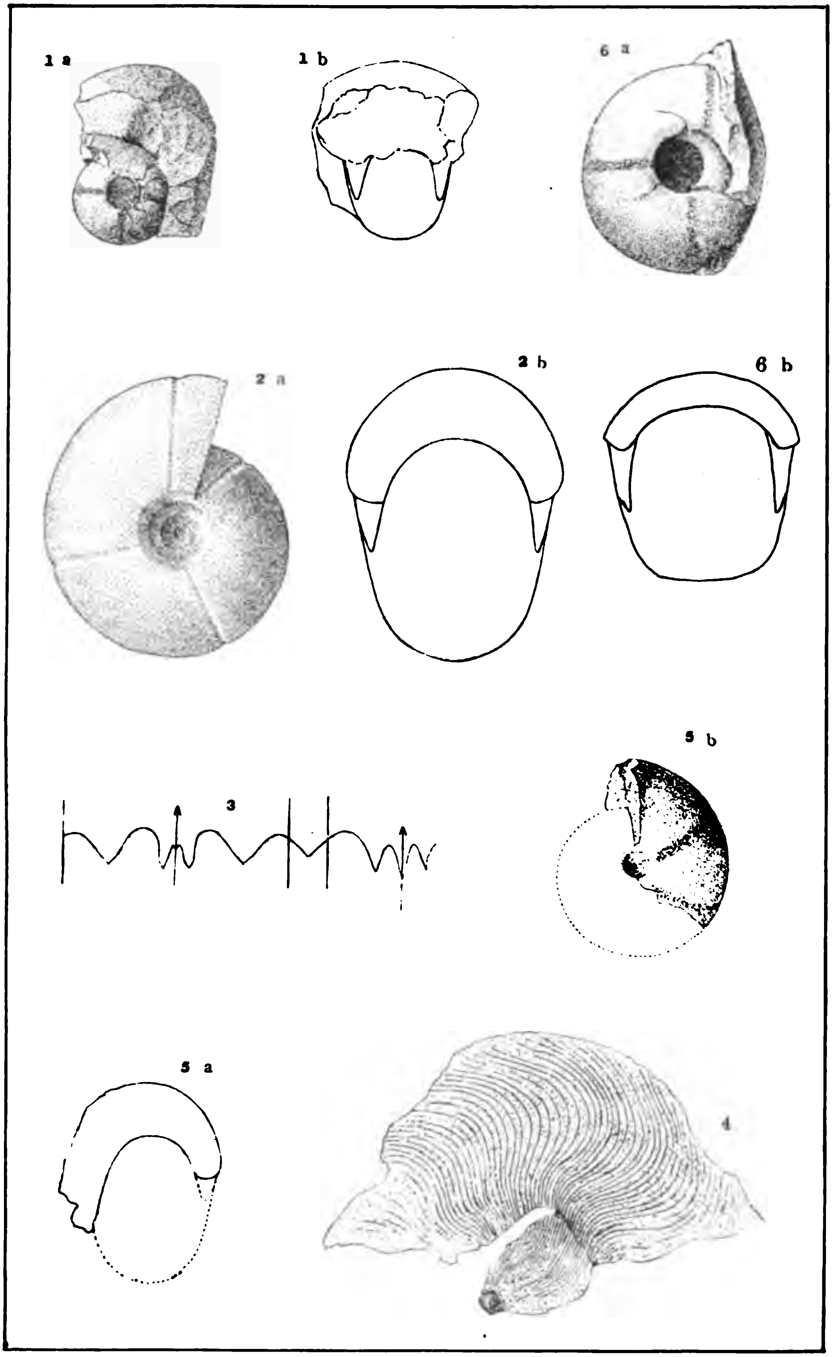
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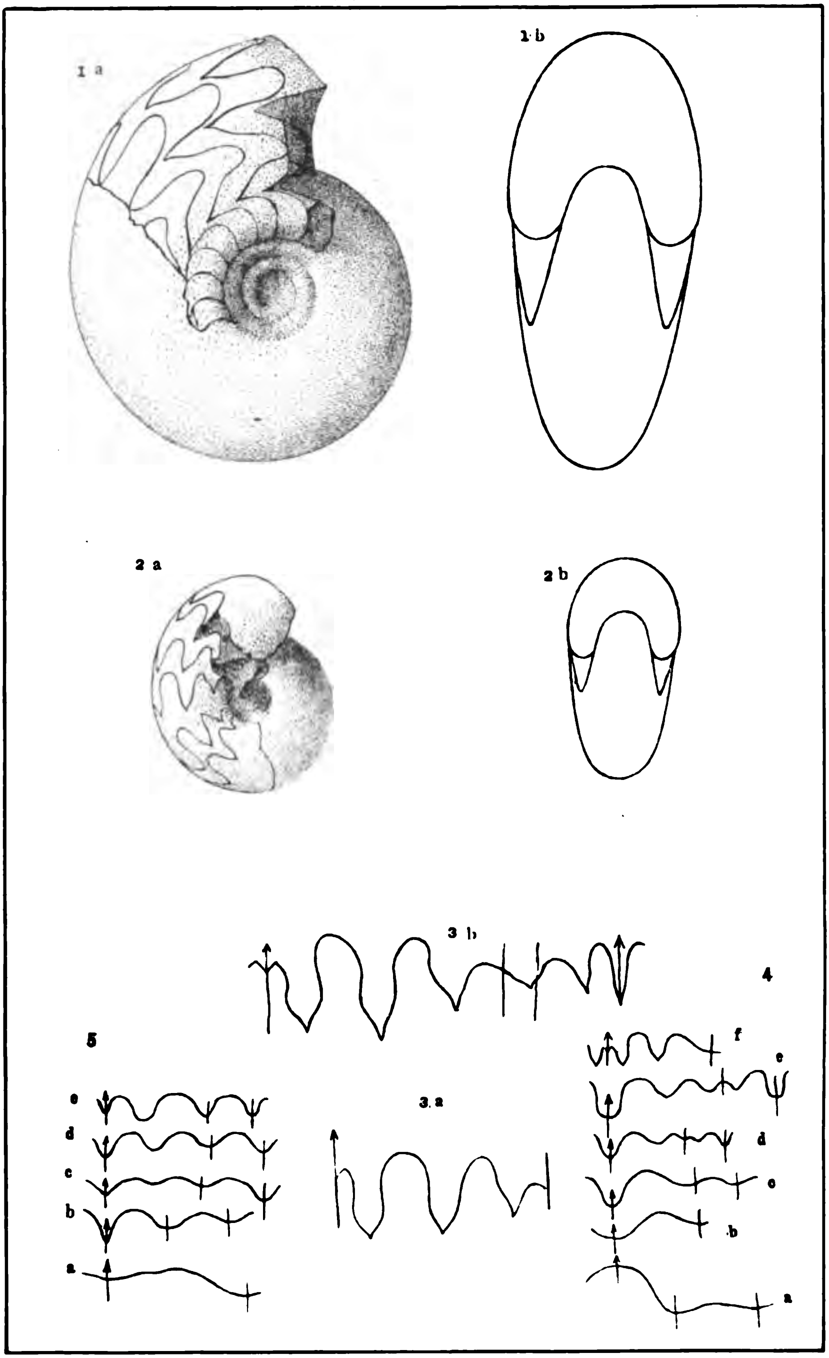
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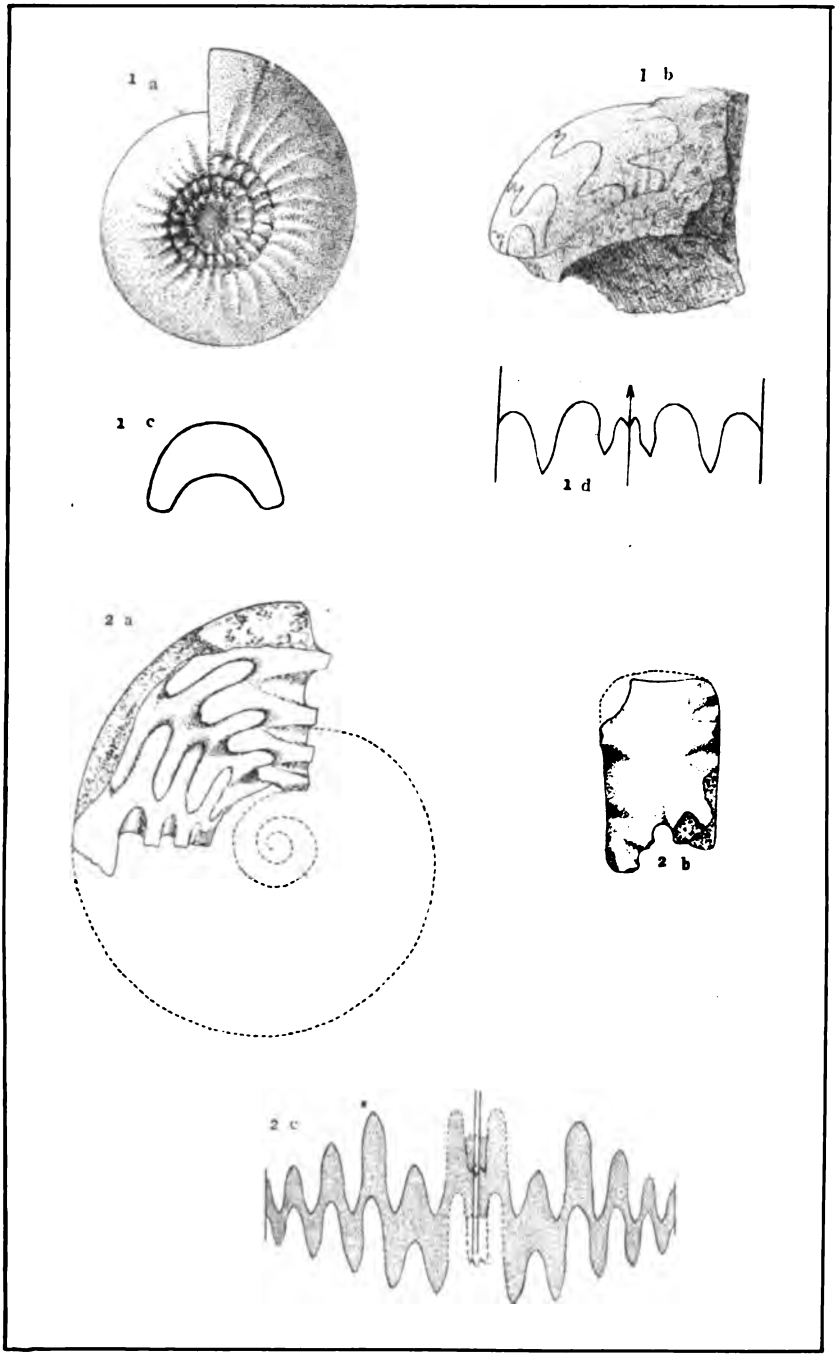
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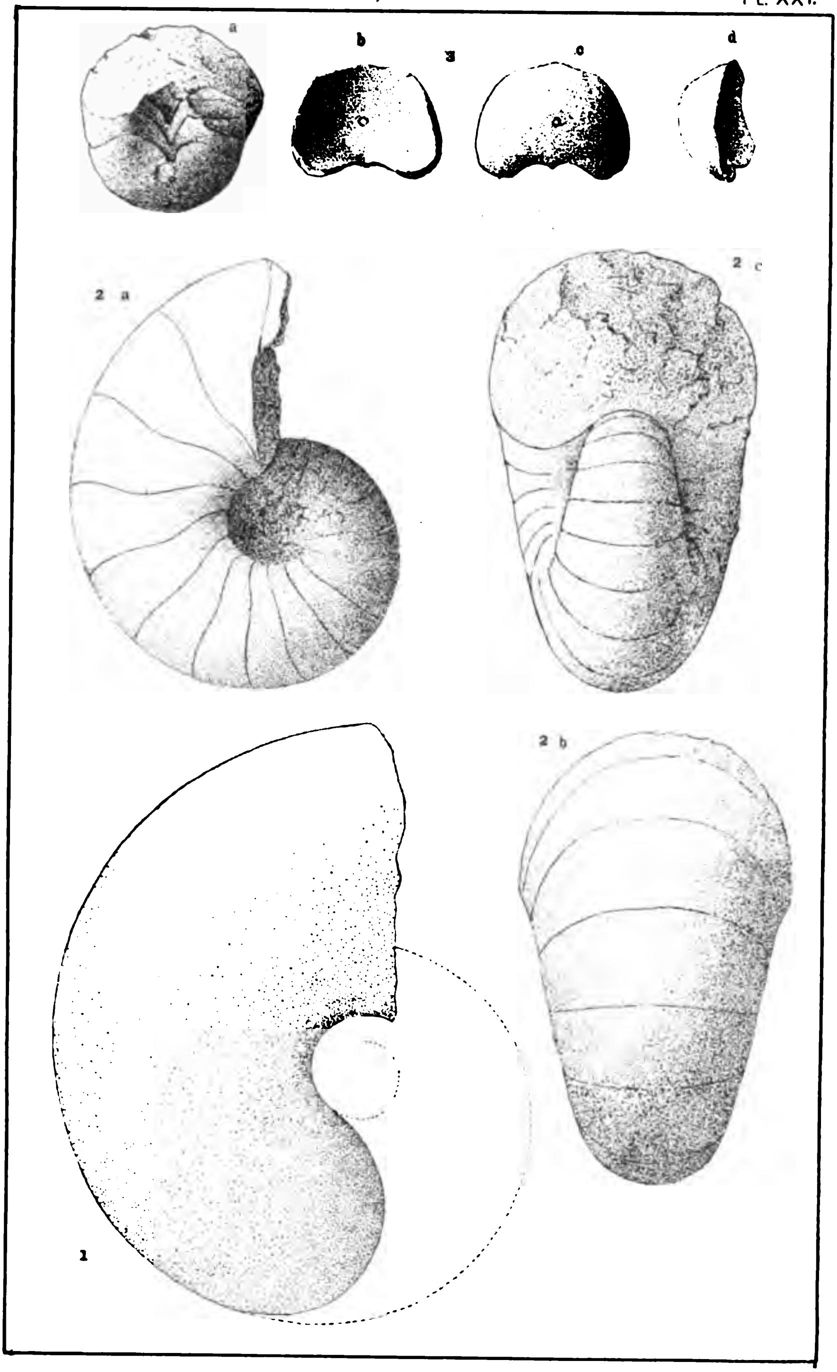
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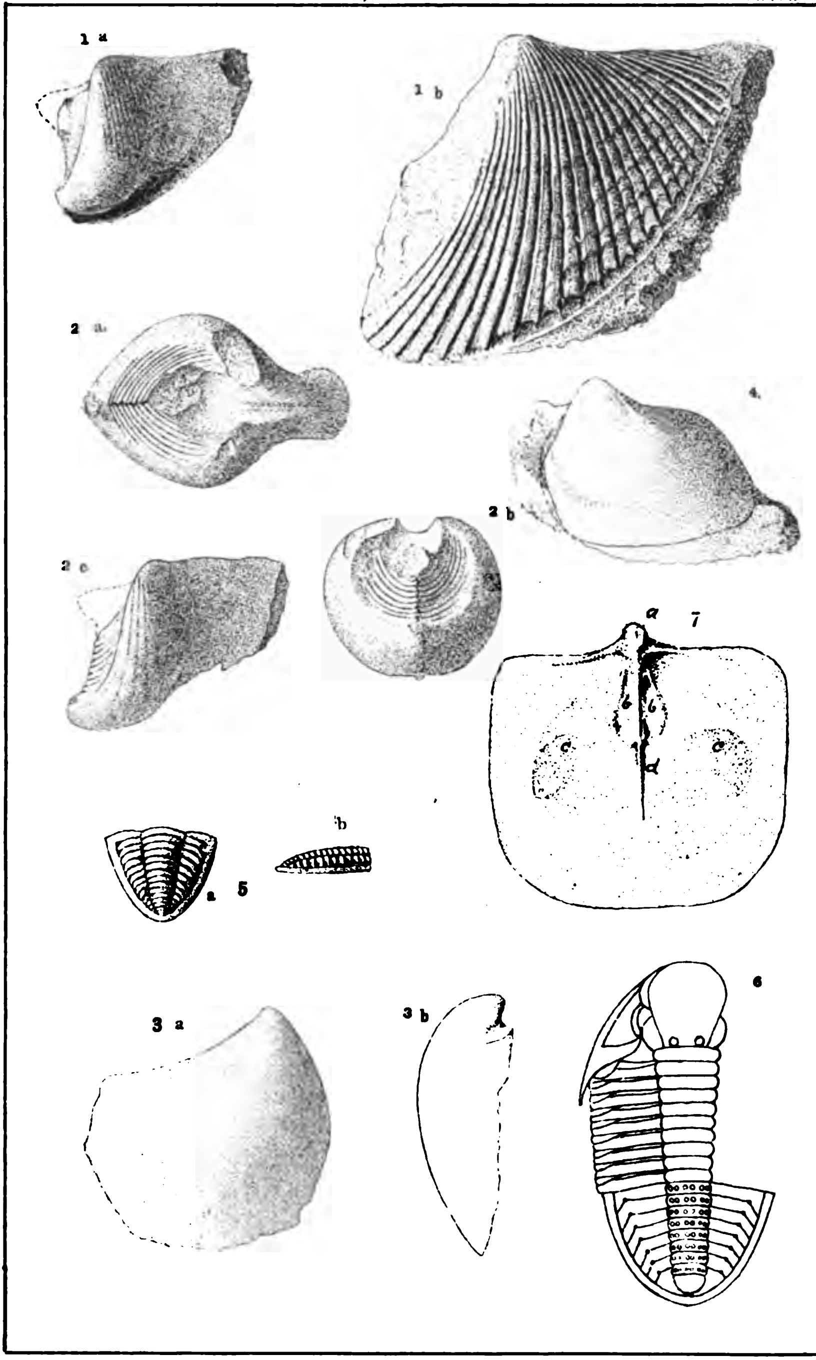
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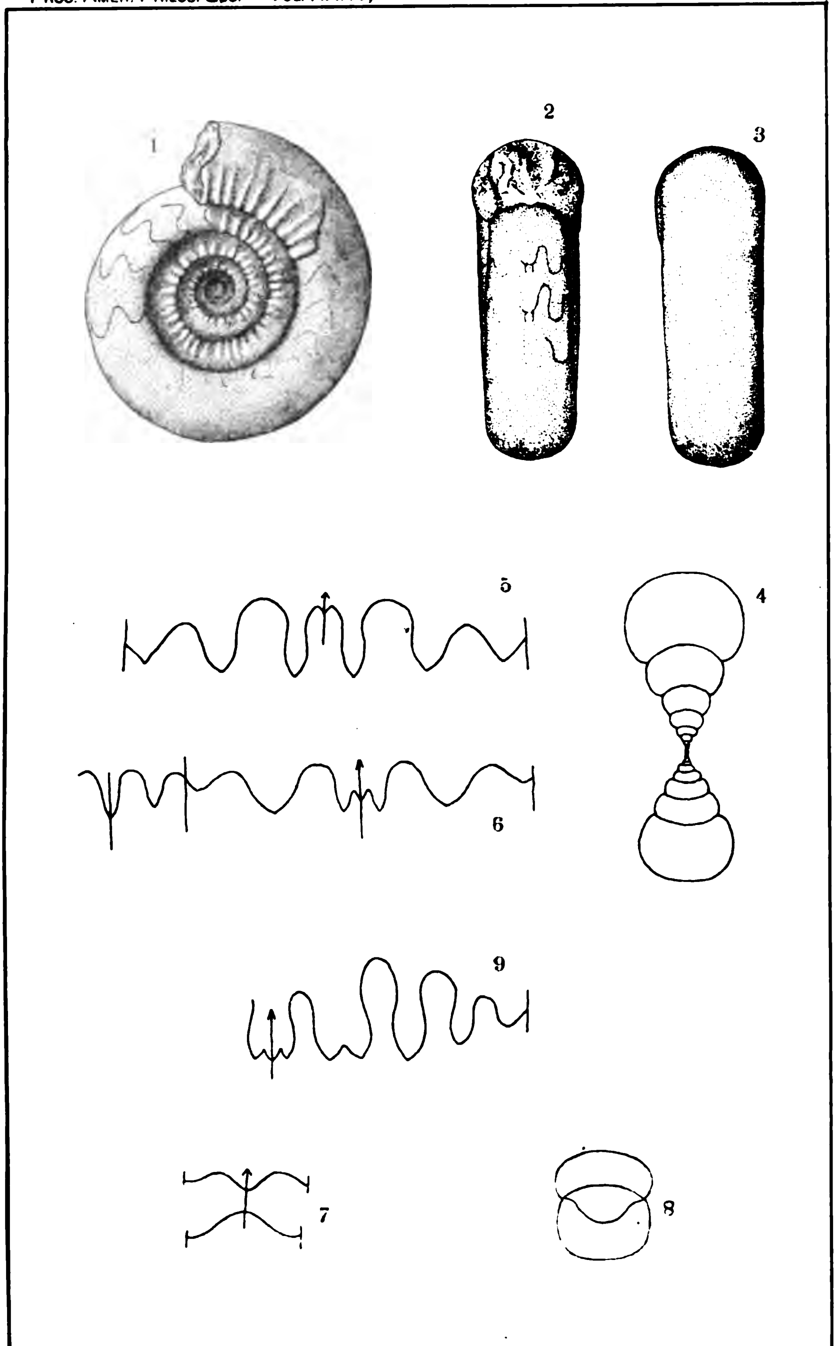
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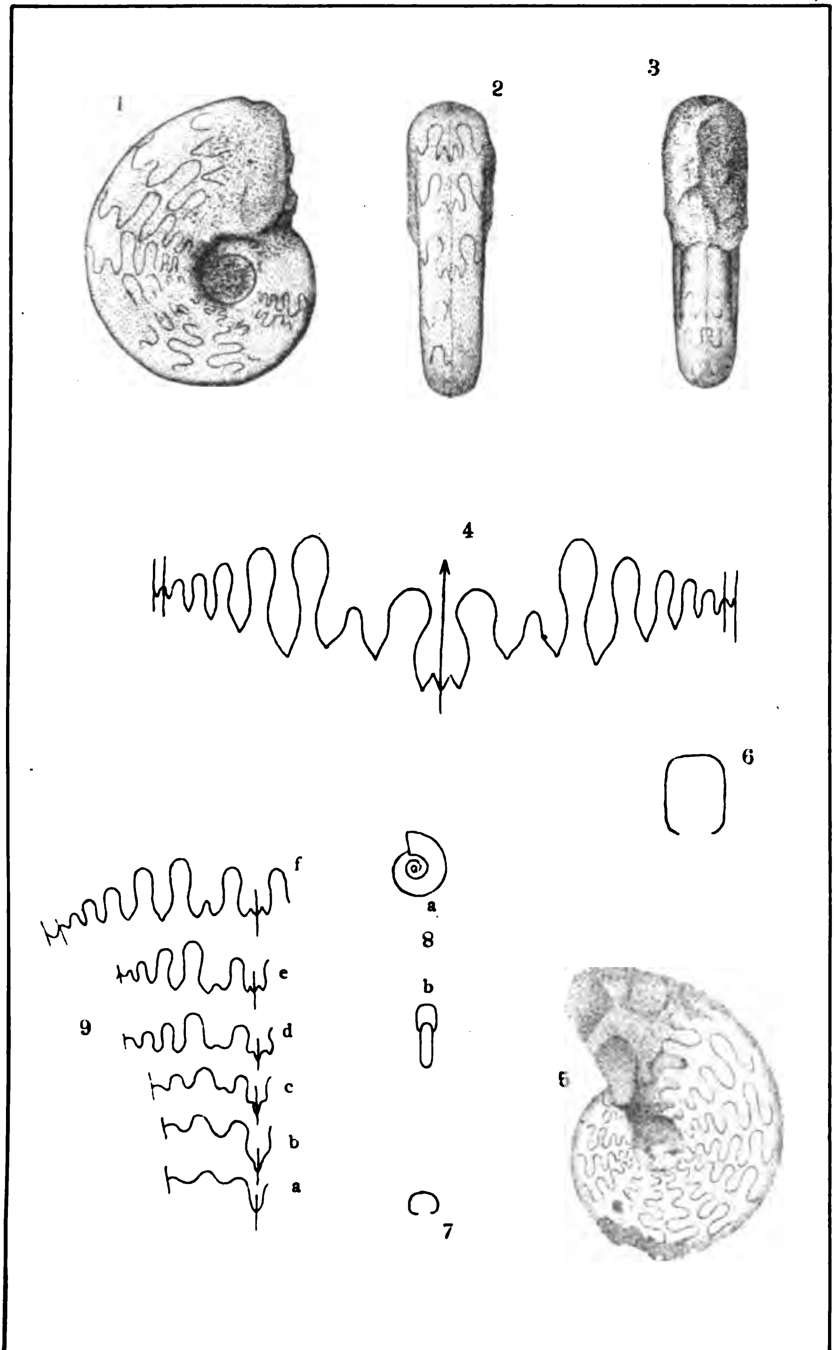
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Plate XXII.

Plate XXIII.

Plate XXIV.

Stated Meeting, October 2, 1896.

The President, Mr. FRALEY, in the Chair.

Present, 13 members.

Minutes of meeting of September 18 read and approved.

The following correspondence was submitted:

Letters of acknowledgment from the Geological Survey, Ottawa, Canada (150); Laval University, Quebec, Canada (150, 151); University of Toronto, Canadian Institute, Toronto, Canada (151); Historical and Scientific Society, Winnipeg, Man. (150); Bowdoin College, Brunswick, Me. (150, 151); Society Natural History, Portland, Me. (150, 151); New Hampshire Historical Society, Concord (150, 151); Prof. C. H. Hitchcock, Hanover, N. H. (150); Hon. E. J. Phelps, Burlington, Vt. (150); Athenæum (150), State Librarian (150, 151), Massachusetts Historical Society (150, 151), Public Library (150, 151), Massachusetts Institute Technology (150), Boston Society Natural History (151), Mr. Stephen P. Sharples (150), Boston Mass.; Museum Comparative Zoölogy (150), Prof. Alpheus Hyatt (150), Prof. F. W. Putnam, (150, 151), Mr. Robert N. Toppan (150, 151), Dr. Justin Winsor, Cambridge, Mass. (150, 151); Free Public Library, New Bedford, Mass. (151); Essex Institute, Prof. E. S. Morse, Salem, Mass. (150, 151); American Antiquarian Society, Worcester, Mass. (151); Rhode Island Historical Society (150, 151), Brown University, Providence, R. I. (151); Connecticut Historical Society, Hartford (150, 151); Yale University (150, 151), Prof. William Gibbs (150, 151), Prof. Arthur W. Wright, New Haven, Conn. (150); Mr. James Hall, Albany, N. Y. (150, 151); Buffalo Library, Society Natural Sciences, Buffalo, N. Y. (150, 151); Prof. Edward North, Clinton, N. Y. (150), Profs. J. M. Hart (150, 151), B. G. Wilder, Ithaca, N. Y. (151); American Geographical Society (151), New York Academy Science (151), New York Hospital Library (150, 151), American Museum Natural History (150, 151), New York Historical Society (150),

Meteorological Observatory (150), Drs. J. A. Allen (151), Daniel Draper (151), Prof. J. J. Stevenson, New York, N. Y. (150, 151); Vassar Brothers' Institute, Poughkeepsie, N. Y. (150, 151); Geological Society of America (150); Academy of Science, Rochester, N. Y. (151); Prof. William Pitt Mason, Troy, N. Y. (150, 151); United States Military Academy, West Point, N. Y. (151); Free Public Library, Jersey City, N. J. (150, 151); New Jersey Historical Society, Newark (151); Dr. W. Henry Green, Princeton, N. J. (151); Dr. C. B. Dudley, Altoona, Pa. (150); Prof. T. M. Drown, South Bethlehem, Pa. (151); Dr. C. F. Hines, Carlisle, Pa. (150); Prof. Martin H. Boyè, Coopersburg, Pa. (150, 151); American Academy of Medicine, Profs. J. W. Moore, Thomas C. Porter, Easton, Pa. (150, 151); Mr. Andrew S. McCreath, Harrisburg, Pa. (150); Mr. John Fulton, Johnstown, Pa. (150, 151); Linnean Society, Lancaster, Pa. (150, 151); College of Pharmacy (151), Franklin Institute (151), Mercantile Library (151), Engineers' Club (150), Pennsylvania Hospital (150), Numismatic and Antiquarian Society (150, 151), Wagner Free Institute (150, 151), Academy Natural Sciences (150, 151), Library Company of Philadelphia (150, 151), College of Physicians (150, 151), Historical Society of Pennsylvania (150, 151), Messrs. John Ashhurst, Jr. (150, 151), R. Meade Bache (150, 151), Henry C. Baird (150), Clarence S. Bement (150), Cadwalader Biddle (151), John H. Brinton (150), Arthur E. Brown (150), Joel Cook (150), Edward D. Cope (150), Charles H. Cramp (151), Samuel Dickson (150), Patterson DuBois (151), Jacob B. Eckfeldt (151), George F. Edmunds (150, 151), Ed. A. Foggo (150, 151), Persifor Frazer (151), Philip C. Garrett (150), F. A. Genth, Jr. (150, 151), A. W. Goodspeed (151), H. D. Gregory (150, 151), H. V. Hilprecht (151), George H. Horn (151), Edwin J. Houston (151), Francis Jordan, Jr. (150), W. W. Keen (150), J. P. Lesley (150, 151), Morris Longstreth (150), Benjamin Smith Lyman (150, 151), James T. Mitchell (150, 151), J. Cheston Morris (150), Charles A. Oliver (150, 151), C. M. Pierce (150), William Pepper (151), Franklin

Platt (150, 151), Theodore D. Rand (151), Julius F. Sachse (151), Samuel P. Sadtler (150), Charles Schäffer (150), Coleman Sellers (150), F. D. Stone (150, 151), W. P. Tatham (151), H. Clay Trumbull (151), William H. Wahl (151), Talcott Williams (150, 151), Joseph M. Wilson (151), Theodore G. Wormley (150), Ellis Yarnall (151), Philadelphia, Pa.; Prof. John F. Carll, Pleasantville, Pa. (150, 151); Mr. Heber S. Thompson, Pottsville, Pa. (151); Rev. Fred. A. Muhlenberg, Reading, Pa. (150, 151); Lackawanna Institute, Scranton, Pa. (150, 151); Mr. Thomas S. Blair, Tyrone, Pa. (150); Dr. Horace Howard Furness, Wallingford, Pa. (151); Dr. John Curwen, Warren, Pa. (150, 151); Philosophical Society, West Chester, Pa. (150, 151); Wyoming Historical-Geological Society, Wilkes-Barre, Pa. (150); United States Naval Institute, Annapolis, Md. (150); Maryland Institute (150, 151), Maryland Historical Society (150, 151), Enoch Pratt Free Library (150, 151), Prof. William H. Welch, Baltimore, Md. (151); Smithsonian Institution (438 pks.), United States Naval Observatory (150), United States Department Agriculture (150), Profs. S. F. Emmons, Charles A. Schott, Washington, D. C. (150); Journal United States Artillery, Fort Monroe, Va. (151); Leander McCormick Observatory (150), University of Virginia (150, 151), Prof. J. W. Mallet, University of Virginia (150, 151); South Carolina College, Columbia (151); Georgia Historical Society, Savannah (150); Cincinnati Observatory (150, 151), University of Cincinnati (150), Society Natural History, Cincinnati, O. (150); Ohio State Archæological and Historical Society, Columbus, O. (150, 151); Denison Scientific Association, Granville, O. (150); Athenæum Library, Columbia, Tenn. (151); Geological Survey of Missouri, Jefferson City (151); Michigan State Library, Lansing (151); Wisconsin State Historical Society (150, 151), Academy Sciences, etc. (150), University of Wisconsin, Madison (151); Field Columbian Museum (150, 151), Western Society of Engineers, Chicago, Ill. (151); Academy Natural Sciences, Davenport, Ia. (151); State Historical Society of Iowa, Iowa City

(151); American Archæological and Asiatic Association, Nevada, Ia. (151); Kansas University Quarterly, Lawrence (150); Washburn College Library (150, 151), Academy of Science, Topeka, Kans. (150); University of California, Berkeley (150, 151); Lick Observatory, Mt. Hamilton, Cal. (150); Free Public Library (150), Academy of Sciences (150), Historical Society (150), Dr. George Davidson, San Francisco, Cal. (150); Prof. J. C. Branner, Stanford University, Cal. (150); Central Meteorological Observatory (150), Observatorio Astron. de Tacubaya (150), Scientific Society, "Antonio Alzate" Mexico, Mex. (150); Meteorological Observatory, Xalapa, Mex. (150); Bishop Crescencio Carrillo, Merida, Yucatan (150); Agricultural Experimental Stations, Kingston, R. I. (150), Newark, Del. (151), Raleigh, N. C. (150), Agricultural College, Mich. (151), Lexington, Ky. (151), Knoxville, Tenn. (150, 151), Manhattan, Kans. (151), Lincoln, Neb. (150, 151), Laramie, Wyo. (150), Tucson, Ariz. (150, 151), Fargo, N. Dak. (151).

Accessions to the library were reported from the Magyar Tudom. Akad., Budapest, Hungary; Physikalisch-Technische Reichsanstalt, Berlin, Prussia; Direzione Generale della Statistica, Rome, Italy; Royal Society of Canada, Montreal; Scientific Alliance, New York, N. Y.; Pennsylvania Hospital, Pennsylvania State Board of Health, Philadelphia; Lackawanna Institute of History and Science, Scranton, Pa.; United States Naval Observatory, Washington, D. C.

The committee appointed to examine the paper on the "Fossils of the Coal Measures of Arkansas," by J. P. Smith, reported in favor of its publication and the Society by vote so ordered.

The following paper was read and referred to the Secretaries for action: "On the Second Abdominal Segment in a few Libellulidæ," by Martha Freeman Goddard.

Prof. Cope then made some comments on a recent paper, "On the Evolution of the Teeth of Mammalia," by Florentino Ameghino.

Pending nominations 1332, 1334, 1357, 1358, 1359, 1360, 1361, and new nominations 1362 and 1363 were read.

Mr. Price, from the Hall Committee, reported the completion of the furnishing of the adjoining room.

The Librarian reported that we were now in possession of a complete catalogue of all the publications of the Society now in stock.

Dr. Hays moved that the Librarian be authorized to purchase at a reasonable price any odd numbers to fill deficiencies in the above list. Adopted.

Dr. Pepper from the Committee on Special Meetings, reported the program for that to be held November 6.

The rough minutes were then read and approved, and the Society was adjourned by the President.

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XXXV. DECEMBER, 1896. No. 153.

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THE AMERICAN PHILOSOPHICAL SOCIETY,

104 South Fifth Street,

1897.

It is requested that all correspondence be addressed

TO THE SECRETARIES OF THE

AMERICAN PHILOSOPHICAL SOCIETY,

104 SOUTH FIFTH STREET,

PHILADELPHIA, U. S. A.

Members will please communicate to the Secretaries any inaccuracy in name or address as given on the wrapper of this number.

It is requested that the receipt of this number of the Proceedings be acknowledged to the Secretaries.

Members who have not as yet sent their photographs to the Society will confer a favor by so doing; cabinet size preferred.

PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY

HELD AT PHILADELPHIA FOR PROMOTING USEFUL KNOWLEDGE.

VOL. XXXV. DECEMBER, 1896. No. 153.

Stated Meeting, October 16, 1896.

Vice-President Dr. PEPPER in the Chair.

Present, 30 members.

Mr. Frank L. Cushing, a newly elected member, was introduced and took his seat.

Minutes of meeting, October 2, read and adopted.

Correspondence was submitted as follows:

A letter from the Society of Colonial Wars inviting us to participate in a memorial meeting to Dr. G. Brown Goode was referred to the President with power to appoint the Committee.

Letter of envoy from the Faculté des Sciences, Marseilles, France.

Letters of acknowledgment from Major Richard C. Temple, Port Blair, Andaman Islands (148, 149); Linnean Soc. of N. S. Wales, Sydney (148, 149); R. Society of Victoria, Melbourne (92); Observatoire, Athens, Greece (143, 146–149); Geographical Society, Tokyo, Japan (148, 149); Soc. pro Fauna Flora Fennica (149), Dr. Otto Donner, Helsingfors, Finland (148, 149); Physico-Math. Society, Kasan, Russia (148, 149); Profs. Serge Nikitin, John Pomialowsky, St. Petersburg, Russia (148, 149); Acad. R. des Sciences, Amsterdam, Netherlands (147–149, and *Trans.*, xviii, 2, 3); Soc. R. de Geographie, Antwerp, Belgium (149); I. R. Accad. degli Agiati, Rovereto, Austria (149); Profs. F.

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C. Branner, Stanford University, Cal. (151); Kansas University Quarterly, Lawrence, Kans. (151); Kansas State Historical Society, Topeka (151); Colorado Scientific Society, Denver (151); University of Wyoming, Laramie (151); Museo de la Plata, La Plata, Argentine Republic (149).

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Announcement of deaths:

Joseph B. Townsend, Philadelphia, October 11, 1896, æt. 75.

Dr. Friederich Müller, Rostock, Germany.

The stated business of meeting being the election of members, Secretaries Frazer and Dubois acted as Tellers.

Nominations 1332, 1334, 1357 were referred to Council on motion of Dr. Frazer.

Pending nominations were then spoken to and the ballots cast.

The Tellers then reported the election of

2297. Harrison Allen, M.D., Philadelphia.

2298. Edson S. Bastin, Philadelphia.

An invitation to the members of this Society to be present at the opening of the new Museum Hall of the Academy of Natural Sciences, Tuesday, October 20, at 3 P.M., was read.

The rough minutes were then read, and the Society adjourned.

Stated Meeting, November 6, 1896.

President, Mr. Fraley, in the Chair.

Present, 34 members.

Minutes of meeting, October 16, were read and approved.

Correspondence was submitted as follows:

Acceptance of membership from Harrison Allen, M.D., October 23, 1896; Edson S. Bastin, A.M., October 24, 1896.

An invitation from the Société Hongroise de Geographie, Budapest, to its twenty-fifth anniversary, October 18, 1896.

Communication from the Museo Nacional de Buenos Aires requesting the supply of certain deficiencies in its set of *Proceedings* of the American Philosophical Society. From Mechanics' Library, of Altoona, asking for deficiencies.

Letters of envoy from the Geological Survey of India, Calcutta; Acad. des Sciences, Cracow, Austria; Gesellschaft z. Beförderung der gesammten Naturwissenschaften, Marburg, Prussia; Central Bureau der Internat. Erdmessung, Potsdam, Prussia; R. Statistical Society, London, Eng.

Letters of acknowledgment from the Asiatic Society of Japan, Tokyo (148, 149); Royal Society of N. S. Wales, Sydney (147); R. Acad. of Sciences, Stockholm, Sweden (150); R. Danish Geographical Society, Prof. Japetus Steenstrup, Copenhagen, Denmark (150); R. Zoöl. Society, "Natura Artis Magistra," Amsterdam, Netherlands (149); Public Museum, Moscow, Russia (149); Imperial Academy of Sciences, St. Petersburg (150); M. Franz Ritt. v. Hauer, Vienna, Austria (150); Naturforschende Gesellschaft, Bamberg, Bavaria (142, 150); K. Bibliothek, Berlin, Prussia (150); K. Geodätisches Institut, Berlin-Potsdam, Prussia (150); Naturwissenschaftl. Verein, Bremen, Germany (150); Naturwissenschaftl. Gesell. "Isis," Dresden, Saxony (150); Naturforschende Gesell., Emden, Prussia (149); Oberhessiche Gesell. f. Natur- und Heilkunde, Giessen, Germany (149);

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Accessions to the Library were reported from the R. Geological Society (Queensland Branch), Brisbane, Queensland; Academia Letterarvin, Cracow, Austria; K. K. Militär. Geog. Institutes, Vienna, Austria; Verein f. Erdkunde, Cassel, Prussia; Naturwissenschaftl. Gesell. "Isis," Dresden, Saxony· Senckenbergische Naturforschende Gesell., Frankfurt a. M.; Gesell. z. Beförderung der gesammten Naturwissen., Marburg, Prussia; Soc. Geol. de Normandie, Havre, France; Soc. des Science Naturelles, La Rochelle, France; Soc. d'Agriculture Sciences et Industrie, Lyon, France; Soc. des Antiquaires, Soc. de l'Histoire de France, École Polytechnique, Paris, France.

Mr. Frank H. Cushing then made a communication on the "Recent Archæological Explorations on the Shell Keys and Gulf Coast of Florida," illustrated by numerous specimens, photographs and diagrams.

Further discussion of the subject was made by Dr. D. G. Brinton and Prof. F. W. Putnam.

The hour of ten having been passed, the Society was adjourned.

Stated Meeting, November 20, 1896.

President, Mr. Fraley, in the Chair.

Present, 44 members.

Minutes of meeting, November 6, were read and approved.

Correspondence was submitted as follows:

A letter from Hon. Mayer Sulzberger, accepting the duty of preparing an obituary notice of the late Joseph B. Townsend, Esq.

Letters of envoy from the Akad. der Wissenschaften, Vienna, Austria; Schlesische Gesell. f. Vaterländische Cultur, Breslau, Prussia; K. Sächsische Gesell. der Wissenschaften, Leipzig.

Letters of acknowledgment from the Royal Society of Victoria, Melbourne (148, 149); Physico-Math. Society, Kasan, Russia (150); Library of Marine Ministry, Prof. Serge Nikitin, St. Petersburg, Russia (150); K. K. Sternwarte, Prague, Bohemia (150); K. K. Central-Anstalt f. Meteorologie, etc., Dr. Friederich S. Krauss, Vienna, Austria (150); Naturforschende Gesell. des Osterlandes, Altenburg, Prussia (150); Gesell. f. Erdkunde, Berlin, Prussia (150); K. Sächs. Meteorol. Institut, Chemnitz (150); Verein f. Erdkunde (150), Mrs. Zelia Nuttall, Dresden, Saxony (147–150); Prof. R. W. Bunsen, Heidelberg, Germany (150); K. Sächs. Gesell. d. Wissenschaften, Leipzig (148–150); Verein f. Erdkunde, Metz, Germany (149); K. Sternwarte, Munich, Bavaria (150); Verein f. Vaterländische Naturkunde in Württemberg, Stuttgart (150); R. Accad. di Scienze, etc., Modena, Italy (149); Acad. des Sciences et Belles-Lettres, Angers, France (148); Soc. des Sciences Nat. et Archeol. de la Creuse, Guéret,

France (148); Soc. Geologique (149, 150), Prince Roland Bonaparte (149), Dr. Edward Pepper, Paris, France (150); Mr. Samuel Timmins, Arley, Coventry, Eng. (150); Prof. I. Legge, Oxford, Eng. (150); Gen. H. L. Abbot, Cambridge, Mass. (151); Geological Society of America, Rochester, N. Y. (151); Oneida Historical Society, Utica, N. Y. (150); Lackawanna Institute of History and Science, Scranton, Pa. (122, 135, 139, 141, 142, 145, 148); Texas Academy of Science, Austin (151); Iowa Masonic Library, Cedar Rapids (149–151); Meteorological Observatory, Xalapa, Mex. (151); Comité Géolog. de Russie (148, 149).

Accessions to the Library were reported from the R. Society of S. Australia, Adelaide; Akad. der Wissenschaften, Vienna, Austria; Schlesische Gesell. f. Vaterländ. Cultur, Breslau, Prussia; Naturhist. Gesellschaft, Nürnberg, Bavaria; Prof. G. de Mortellet, Paris, France; R. Society of Antiquaries of Ireland, Dublin; Royal Society, London, Eng.; American Academy Arts and Sciences, Boston, Mass.; Dr. Charles A. Oliver, Philadelphia; Wyoming Historical and Geological Society, Wilkesbarre, Pa.; Leander McCormick Observatory, Charlottesville, Va.; Department of State, American Anthropological Society, Washington, D. C.; Ministerio de Fomento, Dr. Nicolas Léon, Mexico, Mex.; Lick Observatory, Mount Hamilton, Cal.

A copy of the bronze medal issued by the Kings County, N. Y., Medical Society in commemoration of Dr. Jenner.

Prof. Dr. H. V. Hilprecht made a preliminary and informal statement concerning his latest researches in early Babylonian civilization and chronology and exhibited a number of important antiquities recently acquired by him for the Archæological Department of the University of Pennsylvania, during his stay in Constantinople and Asia Minor. He laid before the Society the earliest written record from Babylonia so far as known. This document, according to Prof. Hilprecht, was written in the sixth millennium B.C. Its ideograms and phonograms are still hieroglyphs. The only document of a hitherto unknown South Babylonian king, *Engégal* of the

fifth millennium, was next treated. A number of the extremely rare Kappadohian tablets, of which more than sixty have been obtained for the University of Pennsylvania through Dr. Hilprecht's efforts during the last four years, a historical document of the time of King Nabonidus and a marble vase of King Artaxerxes with four inscriptions in Persian, Median, Babylonian and Egyptian languages were likewise exhibited and partly interpreted.

Dr. Charles L. Leonard then read a paper on a "New Physical Property of the X-Ray."

Dr. Frazer reported that the preparation of the plates for the reproduction of the signature book would require an additional appropriation of $80.

On motion of Mr. McKean, the appropriation was made.

Mr. Goodwin then moved that the Secretaries be instructed to prepare from the plates now made 250 copies, to be sold only to members at cost, not more than one copy to be purchased by any one member until further orders from the Society. Carried.

Dr. Morris moved that the Society present to the Wistar Institute a bust of Franklin and one of Dr. Wistar, these being in duplicate. Carried.

The rough minutes were then read, and the Society adjourned.

New Physical Phenomena of the X-Ray.

By Charles Lester Leonard, A.M., M.D.

(Read before the American Philosophical Society, November 20, 1896.)

The physical phenomena connected with the x-ray are at present limited to those announced by their discoverer, Prof. Wilhelm Konrad Röntgen. They are their power to penetrate substances formerly considered opaque, their chemical action exhibited upon the photographic film and fluorescent screen, and their power of discharging electrified bodies whether positively or negatively charged.

The simple experiments which I conducted at the Pepper Laboratory

of Clinical Medicine seem to prove that another physical characteristic of the x-ray is now known.

In heating a double-cathode x-ray tube of the focus type, while it was energized by an alternating current, the following phenomenon was noted.

When the alcohol lamp was held at a point midway between the cathodes and at a distance varying from one-half to three inches from the reflectors, the x-ray, as shown in the fluoroscope, and the fluorescence within the tube were seemingly extinguished.

This was true in tube A, and in no other tube of the double cathode focus type.

What was the form of interference which the lamp exerted, and why did it apply to one tube and not to all of that type?

These queries led to the following experiments in which I was assisted by Mr. Alfred Watch.

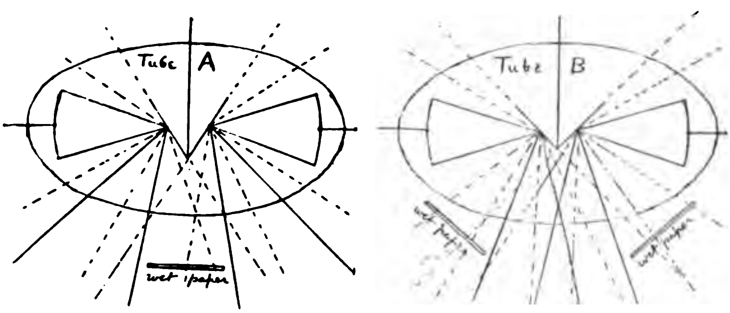


Diagram of X-Ray Tubes. Cathode Rays ————————. X-Rays . . . .

Basing our experiments upon the theory, that it was the aqueous vapor, produced by the combustion of the alcohol, which caused this phenomenon, we substituted for the alcohol lamp a small piece of filter paper saturated with water, and obtained the same result. There was no effect upon the other tubes, the discharge of x-rays and the fluorescence remaining unaltered. On approaching the wet paper to the cathode a streaming of electricity was observed from the paper or lamp vapor towards the cathode through the wall of the tube and was observed to diminish in quantity as the paper was carried towards the point midway between the cathodes and opposite the reflector, and when it reached this point the x-ray and fluorescence ceased. At all points outside the tube a grounded wire drew a spark from the burner of the lamp, or from the moistened paper. This experiment seems to show that there can be established outside of the x-ray tube a connection between one cathode and the other capable of modifying the effect of the electrical discharge within the tube.

This was proved by using a piece of wet paper so shaped that it ex-

tended from cathode to cathode outside the tube. The x-rays and fluorescence were seemingly destroyed in this manner in all forms of double cathode tubes used with the alternating current.

The form of interference which was first observed was therefore the establishment of a path for the conduction of the electricity from cathode to cathode outside the x-ray tube, or in other words the completion of a short circuit between the cathodes in the induced electric field outside the tube.

But why was it possible to complete this short circuit, in one tube, by introducing the aqueous vapor at a single point opposite the reflector and midway between the cathodes, and impossible to do it in any other tube of the same type? Is there any reasonable theory which will logically explain this difference?

A critical examination of two tubes of this type shows that in tube A the cathodes are in such relation to the planes of the reflector that light, obeying the law of reflection, and emanating from the cathodes, would be reflected at such an angle as to leave a wedge-shaped area beneath the reflectors and between the two bundles of rays, free from their interference.

An examination of tube B shows that no such area would be formed, and that the two bundles of rays would be united in the median line.

The fluoroscope shows that this median area is the area of most intense fluorescence, as x-rays enter it from both reflectors.

Suppose the rays obeying the law of reflection within the tube are the cathode rays, which become the Lenard rays outside the tube.

In tube A they would be reflected from the median line and leave a field of x-rays free from their interference. We have then here a purer field of x-rays, which would easily account for the greater rapidity and sharpness of definition which this tube has exhibited, as illustrated by the unintensified half-minute exposure negatives of the hand and other objects, and the six-minutes exposure of the normal trunk of a five-year-old boy.

Would this supposition account for the absence of a conductive area midway between the two cathodes, which, when supplied by the aqueous vapor, results in the extinguishing of the x-ray and fluorescence? It would, if we consider the Lenard rays to be capable of conducting electricity while the x-rays are not. Under these conditions the aqueous vapor between the bundles of Lenard rays, in the case of tube A, would form the connecting link in the short circuit between the cathodes. But how about tube B—if this theory is correct, how can we explain the difference in the phenomenon observed in it?

In this tube we saw, that the bundles of reflected Lenard rays occupied the median field beneath the reflectors and were continuous, while the areas of non-conduction lay between the cathodes and the bundles of Lenard rays.

By placing two small pieces of moistened paper in these two non-

conductive areas, and thus supplying the conductor, the theory is proved to be correct, for the x-rays and fluorescence are seemingly extinguished and we have established the short circuit in both tubes through the medium of the Lenard rays and the aqueous vapor.

The following conclusions may be drawn from these experiments:

1. From the fact that a short circuit may be established between the cathodes in an induced electric field outside the tube, by placing an electrical conductor in certain positions outside the tube, not occupied by the Lenard rays, but occupied by the x-rays, we may conclude that the Lenard rays are conductors of electricity, while the x-rays are not. This would also account for the difference in the action of magnetic fields upon the cathode or Lenard rays and the x-rays, and, conversely, that action would confirm the deduction regarding the conductivity and non-conductivity of the two rays.

This deduction is also compatible with the phenomena observed in the discharge of electrified bodies by the x-ray, the ultra-violet rays, and other forms of light rays.

2. From the condition found to be present in tube A, that is, the presence of an area which is a non-conductor of electricity and is free from Lenard rays, and yet is the area of most intense x-rays, we may conclude that the x-ray emanates from the surface of the reflector in this type of tube, and is not due to the bombardment of the wall of the tube by the cathode rays, as no cathode rays strike the wall of the tube in the area from which we find the greatest fluorescence.

Further, from the fact that the x-ray is a non-conductor and is not influenced by a magnetic field, while the Lenard rays are conductors and are influenced by magnetic fields, it would seem probable that these two forms of radiant energy differ essentially in their character, the x-ray presenting most of the phenomena characteristic of light, while the Lenard rays present the phenomena of radiant matter.

3. From the difference in the rapidity of the action of the two tubes on the sensitive film we may conclude, that the presence of Lenard rays in an x-ray field interferes with the photographic action of the x-ray: consequently a tube of the greatest efficiency would be one so constructed, that the Lenard rays would be reflected entirely outside of the most intense x-ray field.

It would seem probable that the efficiency of the focus type of x-ray tube is in a measure due to such a reflection of the Lenard rays, as many of those working with the single cathode focus tube have found, that the point of greatest intensity of the x-ray is not at the point where rays of ordinary light would be reflected if they emanated from the cathode, that is, the point to which the Lenard rays are reflected, but is at a point perpendicular to the focal point of the cathode rays upon the platinum reflector.

Stated Meeting, December 4, 1896.

The President, Mr. FRALEY, in the Chair.

Present, 27 members.

Minutes of meeting of November 20 read and approved.

Correspondence was submitted as follows:

Invitation from the Chicago Historical Society to attend the exercises at the opening of its new building, Tuesday, December 15, 1896.

Letters of envoy from the Verein f. Schlesische Insektenkunde, Breslau, Prussia; Soc. Italiana delle Scienze, Rome; Department of State, Washington, D. C.; Prof. E. W. Claypole, Akron, O.; Observatorio Astronómico, Cordoba, Republica Argentina.

Letters of acknowledgment from Mr. Samuel Davenport, Adelaide, S. Australia (148, 149); Observatoire phys. Central de Russie, St. Petersburg (150); Societas pro fauna flora fennica, Dr. Otto Donner, Helsingfors, Finland (150); Universitats-Biblioteket, Lund, Sweden (150); Musée Teyler, Harlem, Holland (150, 151); Prof. Edward Suess, Vienna, Austria (150); Redaction der *Naturwissenschaftlichen Wochenschrift* (150), Bot. Verein der Prov. Brandenburg (143, 146, 148), Prof. A. Bastian, Berlin, Prussia (150); Phys.-Technische Reichsanstalt, Charlottenburg, Prussia (150); Naturforschende Gesell., Emden, Prussia (150); Soc. Phys.-Medica, Erlangen, Bavaria (150); Verein f. Geog. u. Statistik, Frankfurt a. M., Germany (150); Oberhessische Gesell. f. Natur- und Heilkunde, Giessen, Germany (150); Verein f. Erdkunde, Metz, Germany (148); Philosophical Soc., Cambridge, Eng. (143, 146–150, and *Trans.*, N. S., xviii, 2 and 3); American Antiquarian Society, Worcester, Mass. (151); Soc. Cientifica, "Antonio Alzate," Obs. Meteorol. Magnet. Central,

Mexico, Mex. (151); Obs. Meteorol. Magnet. Central, Xalapa, Mex. (151); Soc. Cientifica Argentina, Buenos Aires (148, 149).

Accessions to the library were reported from the R. Society of N. S. Wales, Sydney, Australia; Bot. Verein der Prov. Brandenburg, Berlin, Prussia; K. Sächs. Verein f. Alterthümer, Dresden; Deutsche Seewarte, Hamburg, Prussia; Verein f. Erdkunde, Metz, Germany; K. Geod. Instituts, Potsdam, Prussia; R. Instituto Lombardo, Milan, Italy; Soc. Italiana delle Scienze, Rome; R. Acad. Ciencias y Artes, Barcelona, Spain; Philosophical and Literary Society, Leeds, Eng.; Literary and Philosophical Society, Manchester, Eng.; American Oriental Society, New Haven, Conn.; American Museum Natural History, New York, N. Y.; Capt. H. H. Bellas, Germantown, Phila.; Board of Trustees of Drexel Institute, Mr. F. J. Dreer, Dr. Frederick D. Stone, Philadelphia; Acad. Mex. de Ciencias Exactes Fis. y Nat., Obs. Meteorol. y Vulcano del Seminario de Colima, Mexico, Mex.; Obs. Nacional Argentino, Buenos Aires.

Photograph was received for the Society's Album from Prof. E. W. Claypole, Akron, O.

Mr. F. D. Stone read an obituary notice of William John Potts.

The following deaths were announced:

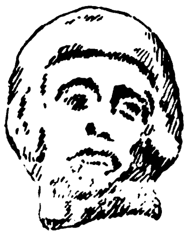
Sir Benjamin Ward Richardson, London, Eng., November 21, 1896, æt. 68.

Dr. Benjamin Apthorp Gould, Cambridge, Mass., November 27, 1896, æt. 72.

Dr. William Pepper exhibited a collection of Mexican prehistoric objects of terra-cotta, obtained by him on his recent visit to the city of Mexico. They comprised a series of miniature clay heads from Teotihuacan, embracing a great variety of types, which were classified by him, for the purpose of exhibition, in accordance with the scheme published by a member of the Society, Mrs. Zelia Nuttall,* in 1886. He

* "*The Terra-cotta Heads of Teotihuacan,*" *American Journal of Archæology*, Vol. ii, Nos. 2 and 3.

exhibited in connection with them some painted clay heads for small images from Canton, China, from the Museum of Archæology and Palæontology of the University of Pennsylvania, pointing out the striking analogy between the Mexican



heads and those from China. The latter are mounted upon bodies of perishable material—of plaited rattan—which is gilded and painted in brilliant colors. They represent personages of the theatre, the emperor, ministers, generals, fairies, etc. The heads are attached to a neck consisting of plaited bamboo in the form of a tube, and have a variety of ornamental head dresses of various materials. Among the Mexican heads shown was one representing a man with a beard, of much strength and beauty of design. The features were apparently those of a European. The general object of the exhibition was to illustrate a parallel usage with that indicated by Mrs. Nuttall in reference to the Mexican heads, and to provoke a discussion of the extremely interesting questions that underlie them. In addition, Dr. Pepper exhibited some very perfect and fragile objects of terra-cotta from Vera Cruz, of a uniformly fine light clay; comprising among others a craw fish and a cup (censer?) with a tall conical cover.

Dr. Brinton expressed the view that these were votive offerings representing symbolic burial.

Dr. Allen referred to the figures as a representation of life form in art.

Dr. J. Cheston Morris made a communication "On Genesis xi. 1–9 as a Poetic Fragment."

Pending nominations 1332, 1334, 1357, 1358, 1362, 1363, and new nominations 1364 and 1365 were read.

The report of the Treasurer was then read and referred to the Finance Committee for examination and report.

Rough minutes were then read and approved, and the Society was adjourned.

On Genesis xi. 1–9 as a Poetic Fragment.

By J. Cheston Morris, M.D

(Read before the American Philosophical Society, December 4, 1896.)

It was with great interest and pleasure that I listened to Dr. Hilprecht's account of his explorations and discoveries recently at Nippur, and to his lucid statement of his views as to the Sumerian and Accadian races and their civilization, and of what he has learned of their history. Especially I regard as important what he had to say of "the land of Shinar" or Sungir. On March 6, 1891, I communicated to the Society some notes on Hebrew Phonetics, accompanied with a transliteration in accordance with them of Genesis x, rendering "Shinar" by "Xnor," v. 10—and am still disposed to adhere to the clue which I think may thus be found to the further elucidation of the history and possibly of the migrations of the ancient peoples. When we read of the building of Babel in the land of Shinar (Genesis xi) by a people that "had bricks for stones and slime (bitumen) had they for mortar," we may well think of a race inhabiting an extensive plain or prairie such as that lying between the Euphrates and Tigris, and building in a different manner from that familiar to the collator of the account, who was probably of a different race—perhaps one of the Semites. His religion too was different, for he speaks of a conference among the gods whom he worshipped, ending with "let us go down and overthrow the tower." A little examination of this account will, I think, show that it is in the form of a Hebrew poem, as is also that of the creation in Genesis i. If so, this account may be that of a victory by a Semite race ascribed to the act of their protecting deity, and the subjugation and dispersion of these lowland people.* Did they, or some of them, migrate to Egypt and found an empire there—building with bricks as they had done in Shinar? Were they the people whose remains were recently described at a meeting of this Society by Mrs. Stevenson as having been discovered by Prof. Petrie? And eventually having been driven thence by the Hamites whom they had temporarily displaced, did they again migrate to the southwest and inhabit the country which to-day we call Senaar? In the Septuagint this is the transliteration given of שנער. Nor is this inconsistent with the softening which must occur in peoples of other races of the guttural-nasal vowel ngain.

I may remark that in the cabinet of the Society are four wooden locks made by the negroes of St. Domingo a hundred years ago. On showing these some time ago to Dr. Hilprecht he remarked to me, "Why those are just such as every Arab sheik has to-day on his treasure-chest or on the door of his house in the valley of the Euphrates." I had no

* For migrations of the brick-builders see McCausland's *Builders of Babel*, London, 1871.

doubt then, that the negroes had learned to make them from their Arab captors and masters in Central Africa and had brought the art with them to the West Indies. But may it not be that their ancestors had brought the art with them from the plains of Babylonia, having migrated thence ages ago, as I have surmised above? If so we ought to be able to trace among the industries, languages and traditions of Central Africa some remnants of this early civilization in the plain of Babylon.

I translate from the Septuagint version of Gen. xi. 1–9 as follows:

And all the earth was (of) one lip,
  And one utterance to all.
And it happened, as they moved from the east,
  They found a plain in the land of Shinar.

And they dwelt there;
  And a man said to his neighbor,
Come, let us make bricks,
  And let us burn them with fire.

And the bricks were to them for stone,
  And the asphalt was to them for mortar.

And they said, Come let us build ourselves a city,
  And a tower whose top shall be to heaven;
And let us make ourselves a name,
  Before we be scattered on the face of all the earth

And Jehovah descended to see the city
  And the tower which the sons of men builded.
And Jehovah said, Behold the race is one,
  And there is one lip to all;
And this have they begun to do,
  And now, nothing will fail them
    Whatever they may plan to do.

Come, and descending, let us confuse their tongue
  That they hear not each one the utterance of his neighbor.

And Jehovah scattered them thence over the face of all the earth,
  And they ceased building the city and the tower.
Therefore its name was called Confusion,
  Because there Jehovah confused the lips of all the earth,
And thence Jehovah scattered them
    On the face of all the earth.

Stated Meeting, December 18, 1896.

Vice-President, Dr. PEPPER, in the Chair.

Present, 34 members.

On motion the regular order of business was suspended and Drs. W. H. Furness and Hiller gave an account of their recent journey in Borneo and the Loo-Choo Islands.

Minutes of December 4 read and approved.

Correspondence was submitted as follows:

Letter from the President of the Geological Society of Washington, requesting the coöperation of this Society with the Pasteur Monument Committee of the United States in collecting subscriptions for the erection of a monument at Paris, to Pasteur.

Letter from the Observatorio Meteorl. y Astron., San Salvador, C. A., announcing the death of its Director, Dr. Don Alberto Sanchez.

Circular letter from M. Julián Aparicio, announcing his appointment to succeed Dr. Don Alberto Sanchez as Director of the Observatorio Meteorl. y Astron., San Salvador, C. A.

Letter of resignation from Mr. E. A. Barber, West Chester, Pa., December 9, 1896. Resignation accepted.

Letters of acknowledgment (*Trans.*, N. S., xix, 1), from the Public Library, Boston, Mass.; American Antiquarian Society, Worcester, Mass.; Yale University, New Haven, Conn.; Buffalo Library, Buffalo, N. Y.; Historical Society, New York, N. Y.; Academy Natural Sciences, University of Pennsylvania, Historical Society, Philadelphia; State Historical Society of Wisconsin, Madison; Kansas Academy of Science, Topeka.

Letters of acknowledgment of Proceedings from the Naturf. Gesellschaft, Dorpat, Russia (149); Tashkent Observatory, Tashkent, Russia (150); R. Zool. Society, "Natura Artis Magistra," Amsterdam, Netherlands (150, 151); Colonial Museum, Haarlem, Holland (150, 151); K. K. Naturhist. Hofmuseum, Vienna, Austria (150); K. Leop.

Carol. Akad. der Naturforscher, Halle a. S. (150); Dr. Paul Heyse, Munich, Bavaria (150); Prof. Paolo Montegazza, Florence, Italy (147); Soc. Géologique de Normandie, Havre, France (150); Soc. Française de Physique, Soc. Philologique, Comte de Charencey, Paris, France (150); R. Acad. de Ciencias y Artes, Barcelona, Spain (143, 145–149); Academy of Sciences, New York, N. Y. (136); Dr. Charles Schäffer, Philadelphia (151).

Accessions to the Library were reported from the Exhibition Trustees, Melbourne, Australia; Acad. Sciences, Cracow, Austria; K. P. Geodat. Institutes, Berlin; Verein f. Erdkunde, Halle a. S., Prussia; K. Sächs. Meteorl. Institut, Chemnitz; K. B. Akad. der Wissenschaften, Munich, Bavaria; Soc. de Physique, Paris, France; Literary and Philosophical Society, Manchester, Eng.; Mr. Edward Waldo Emerson, Cambridge, Mass.; American Museum Natural History, New York, N. Y.; Vassar Brothers' Institute, Poughkeepsie, N. Y.; American Academy Political and Social Science, First Unitarian Church, Philadelphia; Pennsylvania State College; Columbian University, Washington, D. C.; Colorado College Scientific Society, Colorado Springs; Institute of Jamaica, Kingston.

The Wistar Institute acknowledges the gifts of busts of Dr. Franklin and Dr. Caspar Wistar.

The President announced by letter that he had appointed Mr. F. H. Cushing, Dr. Thomas N. Gill and Dr. D. G. Brinton, to represent this Society at a meeting to be held in Washington in memory of G. Brown Goode.

A letter from Mr. Cassell gives the following information: Benjamin Rittenhouse, brother of David, died August 31, 1825, Ninth street above Vine, in this city, and was buried September 2, in St. James' Cemetery, at Evansburg, Montgomery county, Pa.

The Committee appointed to arrange for the quarterly meetings at which subjects of broad philosophic interest were to be discussed made a report of their doings for the year.

The Finance Committee made report that they had examined the Treasurer's accounts, and found them correct. The appropriations for the coming year were recommended, and on motion approved by the Society.

The pending nominations were then read and spoken to, and the ballots cast.

New nominations 1364 to 1369 were then read.

Mr. Price then offered a resolution directing the printing of the ballots for the election to be held January 1.

The Tellers then reported that:

2299. William Francis Magee, Princeton, N. J.;

2300. G. Albert Lewis, Philadelphia;

2301. Benjamin W. Frazier, Bethlehem, Pa.,

had been elected to membership.

The rough minutes were then read and the Society adjourned.

Glimpses of Borneo.

By William Henry Furness, 3rd, M.D.

(Read before The American Philosophical Society, December 18, 1896.)

The island of Borneo, lying directly under the Equator, is the second in size in the world (if we exclude Australia, to which, I believe, is generally given the dignity of being called a continent), Papua, or, as it is now called, New Guinea, being the largest, with an area of 306,000 square miles, while Borneo has an area of 286,000 square miles, or about that of France. Along the coast, and indeed for many miles inland, the country is flat and marshy, covered with a dense tangle of undergrowth, made up of thorny palms, ferns, and creepers of all sorts, including the beautiful variegated Nepenthes, or pitcher plant; above this undergrowth, which is dense to a height of fifteen or twenty feet, rise lofty, straight Camphor, Gutta, Durian and Tapang trees, whose foliage, at least from a distance, is hardly distinguishable from the common trees of our own woods and forests; perhaps the only features which distinguish the Bornean jungle, seen at a distance, from our ordinary forests are the topmost tufts of the Rattan palm, which is a creeper and forms a crown on the tree top, whereof the unexpanded central leaf creates the suspicion that the indefatigable lightning-rod agent had paid a visit

to the primeval forest. Palms as a rule do not enter into the landscape; being of low growth, they are hidden by the lofty trees. Toward the centre of the island there is a broken range of mountains and of high hills running from North to South, the longest diameter of the island; of these mountains, according to our present knowledge, Kina Balu in the North is the highest, and is 13,680 ft. high, but not snow-capped. Other mountains in the chain vary from 3000 to 10,000 ft. in height.

It is in this central range of highlands and mountains that all the numerous rivers rise and form the highways and by-ways of the island, rendering it traversable in almost every direction.

The government of the island is divided between the Dutch in the South and East, The British North Borneo Company in the North, the small Sultanate of Brunei on the west coast, and below this the independent territory of Sarawak, governed by Rajah Brooke, in whose territory the greater part of my time was spent.

In almost every book on Borneo the people are included under the name of Dyaks, either Sea-Dyaks or Land-Dyaks. This is an error. There are many distinct tribes or possibly *races*, scattered throughout the hills and on the rivers of Borneo; they speak a different language, and have different customs of burial, of marriage, of naming children, of boat building, etc., etc. Some show a decidedly Chinese influence, while others are clearly of the Malay type and have adopted the Mohammedan religion in a somewhat modified form; others again are nomadic, and, in appearance, are stronger and slightly taller than the Dyaks, and are not Head-hunters, which is another custom erroneously attributed to all the inhabitants of Borneo.

Borneo is a subject so large that to give a really clear idea of all the intricacies of the manners and customs of its people would occupy far more time than one short evening's talk. Let me rather recount to you what it will be probably impossible to find in books.

Dr. Hiller and myself had the rare opportunity, through the kindness of Mr. Charles Hose, one of the Rajah's most energetic Residents, of spending five weeks among the natives, in the household of Tamabulan, one of the most powerful chiefs of the Kayans and Kenniahs, on the river Baram.

This chief had come down the Baram about two hundred and fifty miles, with a hundred of his men, more or less, to attend a Meeting of Peace and Reconciliation with the Dyaks and other tribes living on the Baram. The Rajah talked to them all most impressively on the evils attending constant warfare, and at the end of his speech, given in Malay—the court language—Tamabulan was the first to step forward and heartily shake hands with the Rajah and express his willingness to do all he could to maintain the peace; which was duly ratified on the morrow by the slaughter of a pig and the examination of the omens as interpreted from the colorations of its liver; yet this same Tamabulan only three years ago was one of the most rebellious up-river chiefs and

had gone on the war-path, without the sanction of the Rajah, and had taken heads, and had barely refrained from killing Mr. Hose who had gone up to put a stop to his marauding.

He is a man of about forty-five, well built, but not muscular in appearance, about five feet six inches tall, his face is broad, the cheekbones somewhat high, the eyes wide apart—owing perhaps to his having his eyebrows shaved, they appear very wide apart; his lips are thin and his mouth large but well shaped, and when he smiles it reveals two rows of regular but blackened teeth. His ears, according to the custom of his people, are pierced in the lobes, and by means of a copper ring, inserted in early childhood, are so elongated that the lobe almost touches the shoulder; his ears are also perforated in the upper part to permit the insertion of a wild cat's tooth ornamented; this is, however, only inserted for full dress; on ordinary occasions he wears therein a plug of wood about half an inch in diameter. These looped and perforated ears serve, in the absence of clothes, the purpose of pockets, and are used to carry cigarettes or even boxes of matches. His hair is straight and black, shaved in a straight line from his temples round his head, but allowed to grow long at the back; it is not unlike a Chinaman's queue unbraided. The skin of the Kayans and Kenniahs, two closely allied tribes, is not yellow, but somewhat darker than a Chinaman's, and they have none of the characteristics of either the thick-lipped African negro nor the bushy, krinkly hair of the Papuans, nor have they the almond eyes of the Mongolians.

As for costume, on ordinary occasions they wear nothing but a loin cloth either of bark fibre or of red or white cotton, bought from the Chinese traders in the Bazaar (the Malay name for a trading post). On their heads they wear a close-fitting pointed cap made of thin strips of rattan (or *rotan*, as they call it) or bamboo dyed red and black and woven into pretty checkered patterns; when they are exposed to the blazing sun they often exchange this skull cap for a broad flat disc made of dried palm leaves and tied to their head.

I describe Tamabulan thus somewhat at length because he is a full-blooded and typical Kenniah, and as *he* is, so are most of his people. They almost universally depilate the hairs of the face, and only occasionally are mustaches or beards to be seen; when they *are* allowed to grow they are more than likely to be restricted to one side of the face, in charming irregularity.

When the peace meeting was over, and the pigs' livers had determined omens propitiously (I think that Tamabulan in his inmost heart thought that the whole thing was foolish and unnecessary, but then the Dyaks were impressed and he was conscious that in any event he was able to overpower them, so on the whole he was well pleased), we returned to Mr. Hose's house, which is a low one-storied frame building, thatched with palm leaves and surrounded with a broad veranda, whereon are scattered in confusion, characteristic of a naturalist, all sorts of specimens,

snakes, fish, scorpions, and animals in jars of alcohol; dried turtles, skulls of wild pigs and of rhinoceroses on the tables and chairs; ornamented war shields and sun hats of the natives decorating the walls. The house stands in a clearing on a bluff about forty or fifty feet above the Baram river (pronounced *Berrem*), which at this point is about 250 yards wide, fairly clear and sleepily sluggish when not disturbed by freshets.

An inspiriting shout from below, and the rhythmical click of the paddles on the sides of the boats proclaimed to us that the Father of the Moon (which is the signification of Tamabulan) and his men had come up from the landing at the Bazaar and were waiting for us by the river bank below Mr. Hose's house. Our store of provisions and the few articles for trading and for ingratiating ourselves with the natives, such as three or four bolts of cotton cloth, sixty pounds of Java tobacco, some bars of steel, etc., were soon carried down to the canoe and stored away, and in the sixty-foot dug-out canoe we were given the vacant space amidships about seven feet long by five feet wide, wherein to spread our mats and make our abode till the end of the trip. The black hard-wood paddles glistened in the sunlight for a moment and then sent the water gurgling and eddying along the sides of the boat as the six men in front of us and the four in the stern, abaft Tamabulan and his goods and chattels, gave a shout and pulled out into the stream. There are doubtless quite a number of Europeans who have made trips into the interior of Borneo, without reckoning the Residents of the Dutch and English companies, but I am sure that no American, and probably no European, has gone further therein than Dr. Hiller and myself or under similar circumstances. We went up the river as the guests of the Chief to be present at the ceremonies and feasting to be given in honor of the Naming of his only son and heir, and during our five weeks there, we lived intimately enough with these jungle-people to get thoroughly into their life and understand their trials and sympathize with them in their joys and sorrows.

Our canoe, as I mentioned before, was about sixty feet long and about five feet wide amid-ships, hewn out of a single log, but deepened considerably by the addition of planks along the sides bound on with rotans and caulked, thus giving about six inches additional free board. The men while paddling sit cross-legged on a flooring of bamboo strips tied together and placed over thwarts about two-thirds up the side of the boat. They seem to be able to keep up an almost mechanical stroke from daylight till dark without showing the least fatigue, and this, too, on two meals a day, consisting mainly of rice and a little dried fish.

Toward dusk of the first day we halted at a sloping sand bank enclosed on three sides by a thick hedge of wild sugar-cane, full of mysterious rustlings, and stretching far over the low ground to the beginning of the jungle. The other boats of our party, numbering eight, were

already tied up to the shore, and the brown-skinned men in their scarlet waist-cloths were bustling about gathering fire-wood and building cranes, whereon to hang their little pots of rice. Soon a row of fires started and the short twilight of the tropics deepened into dark, and the dancing fires cast giant shadows on the gray-green leaves of the wild sugar-cane and lit up the intent faces of the natives with their glistening eyes and brass-studded teeth as they squatted beside the fires and stirred their pots of rice. When the evening meal was ended and they had smoked their long cigarettes of Java tobacco, rolled in a piece of dried wild banana leaf, the moon came up and the embers of the fire were scattered. To become more intimate with them we entered into contests in broad jumping, high jumping and tugs of war, and, alas for me, I was indiscreet enough to turn a hand spring for them and also walked on my hands. (Ever after I was introduced by Tamabulan to his friends with a complimentary remark that I could walk on my hands and turn over, and be it on muddy bank or hard floor I was always obliged to repeat the performance.) Then the chief retired to his boat for the night, and it was a general signal for the breaking up of the entertainment. Grass mats were brought out from the boats and spread on the sand, whereon the men flung themselves for the night in the soft light of the tropical moon, and were soon lulled to sleep by the constant drone and chirp of nocturnal insects. Early the next morning we awoke and saw, by the light of the setting moon, the men shaking out their mats and making preparations for starting off again. We were soon under way once more, and between waking and sleeping we were conscious of the click of the paddles and an occasional shout from Tamabulan ordering his men to paddle faster.

To give in detail all the long days of our trip up the river, and our visits to the different houses, would be wearisome to you, as, even now and then, I must confess, it somewhat was to us. I will abbreviate by saying that there were many hard times. Three men died, of a disease prevalent even here, the Grippe, which then seemed to be epidemic on the Baram river. Unfortunately these deaths were attributed to our presence, and a council was held and we were requested to return, but having already come so far, we begged to be allowed to go on. We distributed tobacco and medicine and held large clinics in our boat for the treatment of an inflammatory disease of the eyes, which was probably due to constant bathing in the muddy river and to not closing the eyes when under the water. The rains descended and the floods came, and for five days we were tied up to the bank, unable to proceed on account of the force of the current and the immense logs which were constantly floating down stream. Then the birds, who are the guides and guardians of these people, were harangued and threatened, and, at one time, an attempt was made to fool them. The whole party pulled up to the bank and disembarked with their spears and parangs, and made quite a circuit through the jungle, so as to make the birds think that they were not going home but were on an ordinary

hunting expedition. On another occasion, Dr. Hiller and myself were sprinkled with water thrown on us from a stick cut into shavings at the end and held on the blade of a parang. Finally, we began the ascent of the Pata river, one of the large tributaries of the Baram, and, after three days of hard boating over rapids which necessitated our disembarking twice and carrying our boat and all our belongings overland for a short distance, we arrived within one turn of the river from Tamabulan's house. Here a short halt for final purification was made, and an arch about five feet high, built of branches, was erected on the beach. Beneath this arch a fire was made, and then Tamabulan, holding a young chicken, which he waved and brushed over all parts of the arch, addressed the evil spirits which had been following us and forbade them to follow us further through the fire. The chicken was then killed and its blood sprinkled over the archway and in the fire, and, led by Tamabulan, the whole crowd filed under the arch, and as they stepped over the fire each one spit in it and immediately took his place in the boats. A half hour more brought us to the huge log which served for a landing along the shore below the house, 900 feet long, of Tamabulan.

The houses of the tribes who live on rivers are always built on high ground above the banks so that they are out of danger from the frequent freshets which occur during the rainy season, and also that they may observe the approach of enemies or friends coming down or ascending the river; to get into the houses you have to walk up a log about ten inches in diameter, notched so as to form rough steps. Let me here briefly describe the tribal and household life of the Kenniahs and Kayans, which, in almost every respect, are similar The inmates of a "long-house" are a collection of about fifty or sixty families banded together for mutual protection and support, and since there must be a centre to every circle one among them is selected as chief, either an old man skilled in war or one rich in worldly goods, which are estimated by the number of heads he owns (these are not marketable but bring good luck), and also by the number of brass gongs and cannons which pass for money; this wealth may be accumulated by successful raids, or by sales of rotan or gutta to the Chinese traders in the bazaar; one of the Baram chiefs has become rich by the possession of a cave wherein the swallows that build edible nests abound. Sometimes the government of a household is hereditary. All the minor details of the conduct of the house are controlled by the Orang Tuah, or the Orang Kaya (the *old man* or the *rich man*), as the case may be; but the affairs of the tribe, such as the advisability of their going on the war-path, etc., are left to the Penghulu, who is responsible only to the Rajah or to his officers. There are but five Penghulus in the Baram district, but there are as many Orang Kayas and Orang Tuahs as there are houses. The long-houses are in point of fact small villages built in a straight line, on high piles, for protection and elevation above the damp ground. Tambulan's is about 350 paces long and rests on piles about fifteen feet high made of magnificent trunks of the Billian tree,

otherwise known as Iron-wood ; some of these posts are at least eighteen inches in diameter stripped of their bark. To enter the house you must ascend, as I have said, by a notched log worn smooth by the passage of many bare feet, and slippery from the constant wetting of heavy dews and frequent rains ; there is no railing. At the top of this rude ladder you enter, under the eaves of the house, the long, wide, general living-room, or street, where most of the life goes on, and where there is a constant haze of smoke and a smell which is a mixture of wet dog and musty garret. The floors of Tamabulan's house are famous, in that they are made of unusually large hewn planks of Billian, some of them being five feet wide, placed rather loosely over the cross beams underneath ; quite a number of the ordinary houses have floorings made of flat strips of the bark of the Nibong Palm.

No nails are used in the construction of the houses, the joists being either notched to fit each other, and then pegged, or bound with rotan ; the roofing is either composed of small shingles of Billian tied in place, or it is made of a thatch of palm leaves ; here and there are trap doors in the roof which can be raised by poles to admit more light and air. The eaves extend down to within four feet of the floor and from them to the floor is built a grating of poles laid lengthwise. This space admits light and air throughout the length of the house. Along this opening in several places are platforms raised about eighteen inches and covered with mats made of woven grasses or strips of rattan. On these the men sit and talk or form interested groups round one of their companions skilled in playing on the Kaluri (one of their most musical instruments, constructed on the principle of the bag-pipe, except that a long-necked gourd takes the place of the dog-skin bag). These verandas or streets are not cheerful places, except close to the opening, where there is plenty of light ; the eaves come down so low that a few feet away from the opening it is rather dark and the beams of the house and the floor are so smoked that all the light is lost in the high roof, where hang hundreds of long bunches of ripening bananas and dusty old rattan traps, like long round baskets, for catching fish, small dug-out canoes warped out of shape, and numerous other native articles, stowed away, doubtless, with the same idea that many an American housekeeper has that they will be useful to some one some day, but that day never arrives and they occupy their place in the order of things as "dust catchers." Opposite to the open ventilation-space is a straight partition running the whole length of the house and dividing the private family rooms from the general thoroughfare ; the openings into the rooms are about twenty feet apart and are about three feet six inches high by two feet wide, at a distance of two feet from the floor ; to enter you must step over this threshold two feet or more high and the door is pulled to with a weight The object of this high threshold is to keep the young children in, and to keep the ubiquitous dog out, neither of which purposes is attended with success.

The living-rooms are even more dingy and smoky than the public pas-

sage-way. On entering Tamabulan's room I was always in fear lest in the darkness I should tread on a baby or a puppy or slip down through the flooring. Once inside the room, however, and over near the light, everything was all right, and Bulan, the eldest child of Tamabulan, and from whom the chief takes his name, (in that country the child is father of the man in cognomen) received us with all the dignity befitting her station, for in point of birth she was a full-blooded princess, although she did only wear one scant garment extending from her hips to a little below her knee, and even this garment was split down one side. She was certainly a most dignified girl, possibly about eighteen, with a mild gentle look in her eyes which she opened and shut with an impressive solemnity; her teeth of course were blackened, but well shaped and regular; her hair was glossy black, parted in the middle and brought down low over her forehead and kept in place by a fillet of plaited rotan around her head; her eyebrows had either been shaved or depilated. The only blot upon her beauty was one of her ears; her over-ambitious parents had put in too heavy weights when she was young, and, alas, one of her beautiful ear lobes had given way; it had been patched, but the patch showed plainly and an ugly lump resulted. Indeed, how true in all climes is it that *Il faut souffrir pour être belle.* I showed Her Highness, Princess Bulan, some pictures of American women in *Harper's Weekly*, which I had brought from Baram to while away the hours in the boat, and she laughed much at the funny custom of squeezing in waists, which I was obliged to tell her was done by means of steel bands laced tightly about them. This seemed incomprehensible to her, and such suffering intolerable. In every picture I had to tell her which were the women when only the head and shoulders were shown; there seemed to be no difference to her in the faces except of course where either beard or mustache marked the men.

The room in which the Tamabulan family lived was much like all the rest; it was large and square with three small closet-like rooms partitioned off; these were the sleeping apartments for the young girls and for Tamabulan and his two wives, and the third was for his slave and his family; they were not neat little rooms with warm tropical breezes wafting in the delicate odors of orchids from the jungle, but black little cubby holes, with nothing but a mat for a bed and the small smoking coal-oil lamp made of tin, or a lump of damar gum sputtering and smoking on a scooped-out stone, for a light. Bulan's room was pathetic in that she had made an attempt at making it a little more dainty by fastening a piece of bright calico upon the wall to relieve the monotony of the darkened wood; she had also arranged some pretty black and yellow bead-work baskets in one corner; these were her wealth. In the corner between Tamabulan's room and that of his slave was the fireplace, merely a flat cake of clay over a few stones laid down on the flooring. There was no chimney and the smoke had to find its way up to the roof or out of the window in the back wall of the house, where there was not

the continuous opening between the eaves and the floor as at the front of the house, but where it was boarded up and light and air were admitted either through small windows or through the trap doors in the roof. From most of the rooms there was also a door and a flight of steps, or rather a notched log, leading down to the rice storehouses behind the house, where the women were occupied every morning pounding the husks off of the rice and winnowing the chaff. In all of the Kayan houses the rice, or paddi, as they call it, is pounded in the house, but the fine flying chaff is not only irritating to the nostrils but sometimes produces an itching eruption on the skin, so Tamabulan very wisely has all this work done out of doors. Everywhere in the house roam most persistently ravenous dogs of the most mongrel type; no one seems to like them and a chance is never neglected to thump them or hit them with a stick. We were warned beforehand by Mr. Hose to tie our boots up to the rafters at night lest the dogs should eat them. What their true use is I never could find out. The men told me they were for hunting, but I never saw them taken out in the jungle nor did they appear to have any master in particular. Beneath the house where the boats, not in actual use, are stored, pigs forage for any stray scraps of food which may drop through the flooring above; and at the back of the house where the paddi is beaten out was always a flock of chickens, kept partly for food and partly for sacrifice; thus in most of the surroundings there is an element of farm life.

While we were off on a visit of five days to a Kayan chief on the Apoh river, Tamabulan had a cozy little room partitioned off for us, and when we returned he led us up to it with pride and told us that he had made the door to fasten, so that the children could not annoy us, but even as he spoke there was a line of beady little eyes peering at us through a crack, and we thought of the small boys who lift the canvas of the circus tent. The small boys were our chief friends, and head of them all, although not by any means the oldest, was the rascally little Adom. There was no feasting, there was no mourning, in fact no incident of interest, complete without the face of Adom peering from his perch on a rafter or beaming out from among the stack of long bamboo water jugs standing in a rack in the corner. Like the mongoose, in Kipling's *Jungle Book*, his motto seemed to be: "Run and find out!"

Let me finish by giving you an account of one day as a specimen of all days spent beneath the hospitable roof of Tamabulan. Would that I could only give it to you with all the distinctness that the mere recounting brings out in my mind!

We awoke with the first crow of the cock, which breaks the silence of the night and dies away in the jungle without the far-off response from neighboring farms, to which we are accustomed in the country here at home. Then a dog rouses up, yawns and stretches and shakes off the ashes of the fireplace where it had been sleeping and begins the daily round of quarrels with its companions. Then the daylight gradually

creeps in and a door slams with a bang at the far end of the house, where the poorer and hard-working people live, and a woman with a bundle of bamboo water vessels slung on her back hurries along to the stairway down to the river. She looks just the same as when she went to sleep. Her dress is the same and her hair is in a disordered tangle, and as she walks her feet come down heavily on the warped planks and make them rattle, no doubt to wake the lazy men, who sleep on and let the women make the fire and get the water while they snooze. Soon she comes back, her hair dripping and glossy and little drops of water still clinging to her skin. By this time there is quite a procession of women going down to bathe and get the cooking water from the river, and there is a slamming of doors and a few wails from the children, and laments from the dogs when they get a thump from a warrior who wakes to find that he has been sleeping with his face close to the dog's mangey back. Then the men who have been sleeping on the raised platform in front of the long slatted window, unroll themselves from their shroud-like coverings of cotton cloth, once white, and a little hum of conversation springs up, possibly a comparison of dreams, the interpretation of which, as in all uneducated classes, has great bearing on their daily life. The mother who comes out with her babies in her arms, or sitting astride of her hips, knows nothing of our custom of caressing with a kiss, but in her maternal bursts of affection she buries her face in the neck of the child and draws in a long breath through her nostrils; in fact, she smells it. In their language the verbs *to smell* and *to kiss* are the same. Then down she goes to the river and takes the morning bath with her child in her arms, sometimes holding it by the hands and letting it kick out its legs like a frog—the first lessons in swimming. One by one the men straggle off to bathe in the river and never miss the opportunity of telling us that they were going to bathe, and when they returned they were also most punctilious in telling us that they *had* bathed. With all this bathing, however, they are not a clean people. Soap is unknown to them and they never use hot water, consequently their skins have not the soft velvety appearance that constant bathing usually produces. We gave some of the girls cakes of Pears' soap, but they ate them.

After bathing there is a lull in the activity of the house, while the married women and young girls cook the morning meal of boiled rice and dried salted fish. (By the way, their method of obtaining salt is, perhaps, peculiar. They burn the stalk of the Nipa palm, which grows in salt or brackish water, and, by soaking the ashes and allowing them to settle, they get a very coarse and dirty quality of salt, of which they are very fond.) In eating they use neither plate nor chopsticks; but, like the Malays, they eat with their fingers, cramming their mouths as full as they can at one time and then taking a pinch of the finely crumbled dried salt fish. They do not eat from one common dish as do the Chinese, but each person has his allotted share piled upon

a thick sheet of the inner bark of a tree (I think it was the tough inner layers of the stalk of a banana), and his portion of fish is placed on another smaller leaf, or if the family is of the "Four Hundred" they may have a pressed glass bowl. The daily meals in the houses (there are usually only two meals a day) are somewhat private affairs, but they always informed us when they were going to eat, probably so that we should not pay them a visit at that time. They likewise always left us to ourselves when we ate. We carried with us a Chinese cook.

After breakfast there were always parties of men and women setting out for the clearings where the rice was planted, and armed with a billiong (the adze-like axe, which they use) and their parang, and their spear, the men go down and get the boat ready, and the women follow after with the paddles, and hampers to bring back bananas or bunches of tender young fern fronds, which they make into a stew. Then the house settles down to the ordinary tasks of weaving cloth or pounding the husks off the paddi by the women, and sharpening spears or decorating parangs by the men industriously inclined; but the latter are rare. They usually spend their time in silly chatter with their companions or merely sit and think, aided by long draughts of smoke drawn deep into their lungs from the strong Java tobacco cigarettes, which they roll for themselves out of banana leaves. Men, women, and children all smoke tobacco, which they grow for themselves, in part, and in part bring from a bazaar far down the river. The boys, ever ready for sport, we used to arm with butterfly nets and send them out in search of insects of all kinds. They knew their haunts much better than we did, and chasing butterflies in the tropics is not the best fun in the world. We much preferred to sit in the shade of the house and fold the insects, when caught, in paper and pack them away in our tins.

Morning wore into afternoon, and then we would sit on the river bank and watch from a high bluff the young girls taking their bath and recreation. Here let me say a word in favor of their modesty. We never saw the faintest conscious immodesty. We used to sit lost in admiration at their skill in swimming. It was a sort of game of tag they were always playing, only, instead of one chasing all, all chased one, and this one would get off some little distance from the crowd and then suddenly disappear under water. Then the chase began. All swam as fast as they could to the spot where she had vanished, some swimming with a rapid overhand stroke, while others swam entirely under the water. Then, possibly still in front of them, possibly far behind them, up bobbed the girl who was "*it*," shaking the water from her eyes and giving a shout of derision at her pursuers. Down she went again and the chase was renewed, all under water, so long, sometimes, that the surface of the river became perfectly smooth, and no one would have imagined that in another moment it would be again bubbling up and dashed into spray by a crowd of laughing, shouting, black-haired savage girls. (We never saw the boys play in the water.) Back and forth,

up and down, they splashed from one side of the river to the other, until one of the men called to them from the house to stop their sport lest they rouse a sleeping crocodile. This put an end to the fun. Another thing, which was quite new to us, was the way in which they could play a sort of tune by splashing their hands in the water and flapping their arms to their sides. They stood in a group, and by sinking their hands back downward in the water and then clapping them above the water and slapping their elbows to their sides, they produced a series of different sounds, like that of a large stone dropping into a deep pool, with a rhythm that was perfect and very pleasing.

Afternoon deepened into dusk, and the workers from the fields came home and trudged wearily up the bank and disappeared through the little doorways. Small flickering lamps were lit here and there, and the fire on the hearth, where our Chinese cook was preparing our rice and tinned meats, disseminated a cheery glow and a smell of frying ham throughout the long corridor, and I am sure that if the ghastly row of human skulls above our fireplace had had chops to lick they would have licked them. At night, according to Tamabulan's orders, no women are allowed out in the public thoroughfare. So if we wanted social life we went round visiting in the evening. A girl named Sara seemed to be the belle of the house, but why I do not know, unless it was her powers of conversation, which, being foreigners, we could barely appreciate. She certainly was not pretty. We much preferred the society of Mujan and her sister Lishun, who always had a good store of cigarettes, and whose stock of Burok, or home-brewed arrack, was above reproach. Mujan gave me her ear-rings before I left, and in return I gave her a cake of soap and a piece of yellow cloth to tie round her head.

Then the household quiets down for sleep, and we secluded ourselves in our little pen and, stretched out on our mats, dozed off, scarcely realizing that we were in the heart of the Bornean jungle in the house of a band of savage head-hunters.

Thus the days passed, and the day of our departure was hastened somewhat by the unexpected change of a festival into a funeral, by the sudden death of a young married woman. Unfortunately this death was also attributed to our presence, and had it not been for the staunch friendship of Tamabulan and some of his men our heads would now be decorating the fireside of a Kayan long-house. We did not know until a while after, when we saw Tamabulan again, what great danger we had been in that night. However, "All's well that ends well," and by the time we were ready to start on our return we were again in good favor, and after a hearty hand-shake all round we bade farewell to dear old Tamabulan and pushed out into the river amid waving of big hats and white cloths, and the long drawn "*Tabé, Tuan, Tabé*" followed after us and echoed in the jungle, even after we had rounded the turn and lost sight of our Bornean friends for ever.

A Brief Report of a Journey up the Rejang River in Borneo.

By H. M. Hiller, M.D.

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The Rejang is the largest river in the north and west side of Borneo —if not of the entire island. Rising in the unknown mountains called Apoh Byang, it falls in rapids and torrents until the Belaga adds its waters; from here it courses a level table land until the cliffs above the mouth of the Balleh are reached and it channels its way through, or dashes over the rocks in a series of rapids and cascades. The stream, from this point influenced by the tide, finds its sluggish way to the sea, confined by low jungle-covered banks, which farther on degenerate into mangrove swamp—and hedges of nipa palms, whose frond-like leaves reach often a height of thirty feet. The general course of the river is from east to west, and, roughly estimating, it is about 270 miles to Belaga —beyond which the distances have not been computed. At Sibu the mile-wide channel breaks into a delta whose mouths extend along the coast for fifty miles. Foreign timber ships enter the deep waters of the delta, while trading schooners and vessels of light draught ascend to Sibu and even to Kappit, a distance of 150 miles—beyond the latter place only canoes are possible and these ascend often with great difficulty, but away in the mountains the Malay and Chinese trader venture in their small canoes.

Sibu is the second town of importance in the province of Sarawak. Consisting of a Malay village, a Chinese bazaar, a fort and the homes of the officers, it guards the upper river from inroads from the sea. Kanowit and Song are unimportant trading stations. Kappit has the added dignity of a wooden stockade, and protects the people between the falls and the delta from the mauruading excursions of the hill tribes. While the detached fortress at Belaga ineffectually keeps the peace between the warlike mountain tribes whose houses extend as far as the river's source.

Between the strongholds are the habitations of Dyaks, Kanowits, Tanjongs, Punans, Kayans and other tribes, their houses being built close to the bank of the stream that acts as a highway. Almost every tributary stream is a branch-road leading back to some settlement where the natives have gone in search of virgin jungle wherein they make clearings for their rice fields.

Crocodiles infest the muddy banks and terrorize the natives, whose efforts at cleanliness are often rudely ended by the sudden rush of the treacherous animal. Deer, wild pig and wild cattle roam the jungle almost undisturbed, for the natives are farmers rather than hunters and the duties of rice cultivation and the gathering of gutta and rattans leave little time for the chase. Yet the presence of many dogs, the

antlers of deer and the horns of cattle decorating their houses, testify to an occasional hunting excursion.

Their methods of cultivation are crude, and often before the planting season arrives they find their store of rice is ended; then they must seek in the jungle for their food; roots, ferns, fruits and any stray animal or bird that crosses their path fall to the blow-gun or spear and finds the way to their cooking pots. But rice is the all-important food, and to secure a full supply all their best efforts are given. Preparatory festivals are arranged, field sites are selected and the omen-birds are consulted, for all the tribes are more or less influenced by the omens; birds, animals and snakes being the chief objects consulted. In fact, scarcely anything of importance is undertaken without first consulting the birds and they abide by their decision no matter what the cost. Half-cleared fields are abandoned, a completed new house is deserted, or a war expedition even is turned back, if some insignificant bird whistles, or a frog is seen at some especial time or place. The subject is intricate, deep and absorbing, and shapes their lives as much as any religion could. But when favorable omens are once secured the clearing of forests goes rapidly forward and the heavy layer of ashes obtained by firing the brushwood and logs acts as a splendid and ready fertilizer. A new field is cleared each year and the old one left to return to jungle again. The grain is planted amongst the stumps and half-burned logs and under the influence of the warm moist climate soon springs into a rich harvest. Yet it is a long and weary way from the planting to the granary, for the beasts and birds levy their tribute and the insects often destroy the remainder and the poor cultivator enters upon a season of starvation, or of debt to the traders, who import rice from Java. Fortunately the sago palm grows throughout the island, and though a poor food still helps to sustain life until the return of the planting season.

One planting season a Kayan chieftain conceived the brilliant idea of planting biscuits. He prepared an exceptional field, secured good omens, strewed Huntly and Palmer's best brand in among the stumps and then marveled that the rare and novel grain did not spring into abundant harvest.

The festivals preparatory to the harvest and following it are usually the occasions for great revelry. All the neighbors come in their boats for fifty and sixty miles, or even further; great quantities of rice-spirit (arrack) having been preparing for a month or more. Huge piles of rice are cooked and many pigs are slaughtered. They eat and drink, then have a series of dances, then eat and drink again; by this time some of the men usually require sleep, so they crawl to one side of the veranda or street, while dancing, drinking and feasting continue.

I remember three old men dancing together after many others had succumbed; shaking a brush in front of them with one hand, a naked parang (or sword) in the other, they brushed out the spirits from all the dark corners and hewed and hacked their imaginary forms. I often

wondered if it was an orthodox dance, or a mild form of delirium tremens. When they are performing their rites and omens they suggest insanity to us. It was at the same feast we saw Dyak women in all their best clothes—gaudy, cheap silk or satin sarongs; a brass cuirass, polished for the occasion, which confined their supple waists and extended over their hips; wonderful caps of rattan frame-work covered with beads which branched in all directions, resembling rare insects. One belle, in addition, wore a wide piece of cloth falling from her neck down her back to her heels—a modified Wateau plait—and the bottom was hung with a lot of old brass bells that banged and jangled against her bare heels at every step. But with all this play they do not forget the birds, and we helped fill the baskets with food which were later hung near the new clearings and the birds come and feed thereon and feel more kindly to the tillers.

In the lower Rejang the Dyaks have become successful farmers, primarily because the soil is more fertile than in the mountains and also because the government forts protect them from the neighboring warlike tribes.

Below Belaga they can plant their paddi or gather their gutta without fear, while above this fort at no time are they ever safe, and they always carry their weapons and keep on their guard lest they be massacred by the marauding bands from over the Dutch border Also in traveling they have the same advantage—where the river is influenced by the tide you see single small canoes going to and fro, while in the upper waters they go in parties of five or six large boats for mutual protection, and also for mutual aid in ascending the rapids: for it often requires their united efforts to haul a boat around a cascade.

You may ascend as far as Kappit in the small government steamers that occasionally go up to the fort for jungle produce, *i. e.*, gutta and rattan. Here you must secure a canoe and a crew of ten or a dozen men; Tanjongs or Kayans are best. In a few hours you pass the mouth of the Balleh, and a short distance above this enter the swift rapids where paddles are useless. Poles are substituted to push the boat over the shallows, while some of the men wade in the stream or walk along the bank pulling at the long rattan which serves as a painter.

This method of progression fails when the falls of the Rejang are reached—a series of small waterfalls with intervening rapids down which the waters rush with irresistible force. Great black rocks or huge wooded islands stand in midstream around the bases of which the water swirls and eddies. Long buttresses resembling walls of masonry thrust themselves almost across the stream and the pent-up current rushes around the end as through a broken dam—or again the rocks rising like a wall form an effectual barrier over which the water tumbles in a number of small cascades. Around these obstructions, or over them, the boats

must be hauled, for they are too heavy to be carried. This labor takes a day at least and often two are consumed before tranquil water permits of the use of the paddle. It requires about two days to traverse the table-land that reaches as far as Dian's house, and nothing breaks the monotony of low jungle-lined shore save an occasional hawk or monkey, nor the intense quiet of the day save the regular click clack of the paddles against the boat's side as they fall in the measured stroke.

When the second rapids are reached, the scenery improves; the low hills are backed by higher hills, and along the reaches of the river the mountains in the interior raise their purple peaks many thousand feet against the sky, rocky banks succeed the low muddy shores and habitations become more frequent. But the ascent becomes more and more difficult, and every mile brings its rapids or small cascade, nor is there any improvement the farther one ascends, and before the last houses are reached the canoes must be abandoned, yet the way still leads up the bed of the stream. The descent, on the other hand, can be accomplished in one-third the time—where you ascended only by the utmost exertion, hauling by rattans, poling or even clinging on with the hands to the stones and branches, you can shoot down at a terrific gait. A steersman standing in the stern and one in the prow guide the boat in and out among the rocks—avoiding the cliffs against whose bases the current seems sure to drive them, or holding the canoe straight as it leaps the small cascades. Few sports are more exhilarating, though many are less dangerous, and the "r-i-p" a jagged rock makes when the boat plunges on it, is not the most musical sound in the world, even to an old boatman, and it is almost certain death to be upset on the rapids.

We secured eleven Kayans to take us from Kappit to Belaga—all young men ranging from fifteen to twenty years old, yet from their life-long experience on the river they were skillful boatmen. We had in addition one child of seven or eight years old, for you seldom see a boat without these nimble and useful assistants. They act as servants to all, in fetching and carrying and are never treated as children, but are made to do a man's part, to suffer and endure as far as their youth and strength will allow. Yet they are not abused, and one and all assist or help them the moment they get into difficulties. The eldest of the party usually acts as head man, deciding on the camping ground, urging the men on to work when they grow lazy or sleepy, and calling them back into stroke when the paddles fail to fall in time. There is usually a wag, who keeps them all merry and often relieves the tedium of the long afternoons by reciting deeds of valor, anecdotes or even jests, while at the end of each line the others join in a chorus and for the time fatigue is forgotten and the paddles fall in rhythm.

There are others who say but little, yet who move to the prow and stern as steersmen when the dangerous places are reached. Some are

friendly, lending a hand at fire making, wood gathering or fastening the boats, while others look out for themselves alone. You soon come to know them all—their names, Lejau, Blari, Deng, Terluat and Leshon; their peculiarities, and their worth, and the fact of their being untaught savages, negligent of dress, careless of life, be it yours or theirs, fades, and they enter into your life, as did your early playmates or your college friends. One youth soon attracted our attention, on account of his happy disposition and his utter unselfishness, and we could always recognize him by his red flannel jacket cut in the Eton style, the abbreviated skirt of that time-honored garment being still further reduced so that it fell but a short distance below his shoulders. We were a party of half a dozen boats, in one of which were some Punans suffering from malaria. The Eton boy constituted himself nurse and cook for them, though they were utter strangers. Our own cook was a Chinaman, and all day he suffered from teasing at Deng's hands, yet when camping time arrived the celestial found his wood collected and fire already started by his never-tiring friend.

If possible we camped near a house, and in the evening we would visit the head man and make a small exchange of presents, usually a chicken on his part and some Java tobacco on ours, but more often sundown found us tied up to a bank, if possible near a small brook. In no time a dozen small fires would be blazing over which each man's small pot of rice was suspended, each person squatting near by tending his fire and waiting for the pot to boil; even the child had his individual pot, while the Chinaman usually required two or three for his more elaborate efforts. We usually sat apart on a log or stone watching them, listening to their chatter, to the vesper songs of the birds, the good-night of the argus pheasant, or the fluttering of the jungle fowl as it flew into the trees to roost. I heard also the awakening of the night chorus of cicades, frogs and birds while watching the sunset in all its golden splendor. As the twilight deepened into night the colors faded and the stars came out like lights in the sky, and the southern cross hung high over the trees. The Malay trader spread his mats and facing Stamboul muttered his prayers as the sun went down. The Kayan child early curled up in the boat to sleep, and one by one the boatmen wrapped themselves in their thin cotton sarongs and stretching out on the stony bank slept the sleep of tired men. The river added its gentle murmur to the night chorus, and ever and anon the "night-jar" raised its plaintive notes to tell that it kept its vigil while the jungle slept.

Beyond Belaga it was considered dangerous to venture on account of the war between two great rival tribes, but finding a friendly chief returning home we took advantage of the occasion and accompanied him. A day's journey we came to the long-house of a former king, now practically deserted because of the planting season, and the men and

women were then living in temporary houses near their distant fields. Even the king's apartments were vacant, for with the changes war and disease ever bring, no heir is left and another dynasty has ended. In front of his door a great slab from the tapang tree indicates his former dias. Quaint, characteristic, Kayan carvings decorate the empty dwelling and the dogs now go in and out without hindrance or molestation.

Oyang Usa's house was the farthest point reached on the Rejang, perhaps 300 miles from the sea, and in the distance the blue mountains mark the foot hills of the range where the river takes its source. No white man has yet visited the spot.

As we descended the river we fell in with some of the warriors returning, and in course of time elicited some facts concerning the recent expedition; tales that rivaled the Indian stories of our childhood. They showed us their trophies, their plunder and their fast drying heads, and lastly with a petition for food they produced a two-year-old captive child whose mouth watered as hungry children's do, when we offered it a bit of food. We floated down the river side by side for several hours, and before we left that baby had a generous half of our stores at its command.

Captives, however, stand second in rank among the spoils of war; a dried and charred head perhaps yielding to no other object, especially when at the feasting and drinking that follows the return of an expedition the women take down the heads from over the fireplace and, dancing up and down the veranda, hey sing of the courage of the successful and taunt those who from want of skill or valor returned empty-handed. Then too they often get quantities of mats, of old Chinese jars, by which they set great store, of weapons of all sorts, and occasionally a rare find in the shape of a string of dingy beads

These curious old glass beads have fictitious values in their eyes, a single small bead called by them a "Lukut Sekali" may cost as much as a slave, or if you ask the price of a necklace it goes beyond their powers of computation, and the person after thinking for a while will usually say it is worth more than a long-house. They are supposed to be Venetian beads, brought to the east by Mohammedan traders and sold by the Malays and Chinese to the Kayans. The Chinese have tried in vain to counterfeit these beads as well as the old jars, but the Kayan is an antiquarian of no mean skill in the matter of glass and porcelain and the Celestial has not yet succeeded.

On this same expedition some of the Dyaks found the "safe deposit" of a friendly chief, but thinking it the hiding place of their enemies they raided it. At the request of the government they returned the property to the owners, and on this occasion we saw for the first time the "tebuku" or memory knots common to many untaught people. In this instance a bundle of rattan strips tied in knots recording the various

gongs, spears, shields, mats, etc., were strung together in a hopeless tangle, but when the chief, squatting on his mat before the officer, gradually untangled the various pieces, each knot recalled a definite object to him, and he detailed the hundred or more articles without once faltering.

The Punans are an interesting people and differ in many respects from their neighbors. Many travelers consider them the aborigines of Borneo. They are mostly strong, lithe and active, even distancing the strongest Kayan or Kenniah in traversing the jungle. They are nomads, living but a few days in one place, making a shelter that cannot be called a house and abandoning it as soon as jungle produce or game proves scarce, for they are hunters and not farmers, and in this respect they differ from almost all the other tribes. To them also is attributed the first use of the blow-gun and poisoned arrows, and they still can excel the other races, who have adopted this effective weapon. A piece of tough wood about seven or eight feet long is drilled by means of an iron rod so that a perfectly straight tube is made having a diameter of about half an inch. If there should be any curve an iron spear head of the proper weight is bound on one end by means of rattans so that the weight springs the shaft into a perfect line, and they now have a spear and blow-gun combined. The dart of about one foot in length is made from the tough nibong palm and another palm furnishes the pith with which the head of the dart is finished, it being just a shade smaller than the calibre of the tube. The sharpened end of the dart is then dipped in the inspissated juice of the upas-tree, and one of the most deadly and at the same time silent weapons is prepared for use. A short quick puff and a man at seventy-five yards distance feels a prick in his side, he plucks the dart away or plays idly and foolishly with the broken shaft, gradually his motions become more and more incoördinate and he falls to the ground unconscious, and a few convulsive movements ends his career.

They are no less adept in the use of the spear or the parang, as they call their substitute for a sword, than their rivals. Yet sickness, famine and war are rapidly thinning their ranks, and unless they are fostered by the government it will be but a few years until the nomad Punan is forgotten.

They are the only people in Borneo who practice polyandry. The Ukits are a similar tribe and can be distinguished by the singular shield-shaped breast tattooing. They, too, live in a very primitive dwelling, usually built against the buttress of a big tree, which scarcely keeps them dry during the rains.

The story of Bululuk Sabon's misfortunes will give you an idea of how uncertain and dangerous life can be in a Kayan house near the border. Bululuk was a small man, but gained great credit among the people and eventually became their chief. When Mr. Lowe suddenly appeared

in the head-waters of the Rejang, he shamed the people because their houses were poor. So Sabon built a new one that strangers might admire. That was many years ago, and Mr. Lowe's visit remains the first and last, but the house decorated with carvings and having hewn board floors still stands expectant. In the meantime, while many of the men and their chief were away down the river, the Kenniahs came over and killed all the old and very young who could not escape into the jungle. Seven doors remained closed thereafter. Not satisfied with this success they came a second time. His wife, his mother and his child fell in the night attack, and he, with his ten-year old daughter Liban, made his escape. A few more doors were rendered useless after this depletion. Gathering all the fighting men he could command he joined hands with the Dyaks in their recent raid and endeavored to wipe out the score. When we saw him again returning to his almost deserted house his little daughter accompanied him. He was very poor; must even sell his best blow-gun to obtain food. But nothing daunted, he was going back to tend his rice fields, and, if by any chance he found an opportunity, he would take a few more Kenniah heads to avenge his people.

By contrast the life in a Dyak's house, or in a Malay village, may be as tranquil as in our own country, and there the petty annoyances of every-day life assume as large proportions as do the struggles for existence at the sources of the rivers. They feast and dance and make merry, while Bululuk Sabon keeps watch and ward over his half-emptied house.

If we dared prophesy as to the future of the Rejang's people, we should say, that in proportion as the sturdy hill people dwindle away, the more fortunately situated coast tribes would bear their advancing civilization towards the mountains, and as the country becomes more and more settled, when tribal wars are ended, and a better knowledge of rice culture prevails, they should become a prosperous people.

Exploration of Ancient Key Dwellers' Remains on the Gulf Coast of Florida.

Plates XXV–XXXV.

By Frank Hamilton Cushing.

(*Read before the American Philosophical Society, November 6, 1896.*)

Introductory.

Early in the spring of 1895, Captain W. B. Collier, of Key Marco, southwestern Florida, found, while digging garden-muck from one of the little mangrove-swamps (Section 14, Plate XXXI) that occur, like filled-up coves, among the low-lying shell-banks surrounding his shore-island home, several ancient wooden articles and some pieces of netted cordage. He did not recognize as of artificial origin the first found of these objects—so softened were they by decay, so like the water-soaked fragments of rotten timber and rootlets everywhere encountered in the muck. But the twine-like appearance of some of the seeming root-strands that clung to his digging tools, and the discovery, a little later, of a beautifully shaped and highly polished ladle or cup made from the larger portion of a whelk-, or conch-shell, led him to believe that the strands were actual cordage, and that a noticeably curious block of wood, which had been sliced through by his spade and cast aside, was really an article fashioned by man.

A few days later, Mr. Charles Wilkins, of Rochester, N. Y., chanced to sail down that way from the little winter resort of Naples, some fifteen miles north of Key Marco, to seek for tarpon, and thus to hear of this find.

Another guest at Naples, a traveler of wide experience and an accomplished scholar withal, Lieutenant-Colonel C. D. Durnford, of the British Army, had organized, a few days previously, an amateur expedition to explore an ancient canal and several small burial mounds near by. In this expedition, Mr. Wilkins had joined. He was therefore much interested in what he heard at Marco, and passed a day in digging there on his own account. He found close to the place that had been opened by Captain Collier and his men, other remains, including portions of two wooden cups—one of them somewhat charred—another shell ladle, several pierced conch tool-heads, and a fairly well-preserved animal figure-head of carved wood. When told by him of these finds, Colonel Durnford, accompanied by his courageous wife, immediately set forth for Marco. He had two small excavations made (in Sections 32, 33, Plate XXXI) as close to those that had previously been made as was possible—for these holes were now flooded with water. Therein, he found a piece of rope, more netting, fragments of gourd-shell, a couple of well-worked little blocks, and a tray of wood, some pegs fastened together with string, two billets, what he regarded as remnants of a "fish-bone necklace," and a neatly pierced bivalve shell.

His antiquarian curiosity regarding these things was thoroughly aroused. But believing them to be the remains possibly of some old-time wreckage, or more probably of some casual deposit made by ancient fishermen and never recovered, and finding work in the water-soaked, foul-smelling muck most difficult to pursue, he discontinued his researches on the second day. In order, however, to ascertain whether the relics he had secured and in part brought away were historic or prehistoric—that is of the Spanish or of a purely aboriginal period—he called at the Museum of the University of Pennsylvania, when passing through Philadelphia some weeks later, to see the Curator of the American Section of the Archæological Department, Mr. Henry C. Mercer, whom he had met in southern Europe a year or two previously. Mr. Mercer was absent, but it chanced that during the same hour I, too, called at the Museum to pay a brief visit to my friend there, the Director, Mr. Stewart Culin. Thus I was so fortunate as to hear Colonel Durnford's account of the finds. I was also privileged to accompany the President of the Department, Dr. William Pepper (for I was at the time on sick-leave and under his care), when, in response to a courteous note of invitation, he called on Colonel and Mrs. Durnford, at the Bellevue Hotel. With him I saw some of the Marco relics, the piece of rope, the tray and one of the worked blocks or billets of wood. I observed that the rope had been slightly charred at one point, and that the billet was an unfinished object. This, with Colonel Durnford's remarkably clear memoranda and description of the place whence these relics had been derived, led me to infer that it, the place, was not of an isolated character. The relics themselves were indubitably Indian and pre-Columbian. To me they evidenced remote aboriginal occupation, residence that is of the actual site in which they had been found, rather than of merely the neighboring shell-banks. I believed, indeed, that their condition and their occurrence beneath the peaty deposits of muck might even betoken some such phase of life in southern Florida as that of the Ancient Lake Dwellers of Switzerland, or of the Pile and Platform Builders of the Gulf of Maracaibo or the Bayous of the Orinoco in Venezuela.

I, therefore, did not hesitate to assure Dr. Pepper and Col. Durnford of my opinion that the find to which he had drawn our attention would, if fully enough followed up, lead to the most important archæological discovery yet made on any of our coasts. Dr. Pepper also attached great significance to the find. He straightway expressed the wish, indeed, that in the interest of the Department he represented, a reconnaissance of the place, as well as of the surrounding region, might immediately be undertaken, with a view to still further explorations another year, in case my conclusions as to the typical nature of the field were thereby borne out. As Mr. Mercer was loath to leave other and pressing work, I eagerly volunteered—health being equal and consent of my Director in the Bureau of American Ethnology, Major J. W. Powell, being granted—to

undertake such a reconnaissance. With that rare public spiritedness, instant foresight and promptitude for which he is so distinguished, your honored Vice-President, Dr. Pepper, forthwith provided funds and otherwise arranged for this preliminary survey by me.

Thus, and through the kind offices of the late Hamilton Disston, Esq., and Col. J. M. Kreamer and their associates, I succeeded in securing, from the Clyde Steamship Company and from those courteous gentlemen of Jacksonville, Col. J. K. Leslie and Major Joseph H. Durkee, passes all the way from New York to Jacksonville, and, by way of the St. John's river to Sanford, and thence by rail diagonally down through the pine lands and the tropic lowlands of Florida, and found myself, within less than a fortnight, at the little town of Punta Gorda, near the mouth of Pease river, a deep tidal inlet, on the gulfward side of that State.

First Reconnaissance.

Description of the Ancient Keys or Artificial Shell Islands.

I was not much delayed in securing two men and a little fishing sloop, such as it was, and in sailing forth one glorious evening late in May, with intent to explore as many as possible of the islands and capes of Charlotte harbor, Pine Island Sound, Caloosa Bay and the lower more open coast as far as Marco, some ninety miles away to the southward.

The bright waters of these connected bays and sounds formed a far-reaching and anon wide-spreading, shallow inland sea. It was hemmed in to the westward by a chain of long, narrow, nearly straight, palmetto and forest-clad reefs or islands, just visible on the horizon; but, as I later learned, all of sand, save only for occasional capes or promontories of shell that here and there jutted forth into the wide mangrove swamps that everywhere closely invested their inner shores. The shores of the opposite mainland and of Pine Island too—which, intervening, hid them for miles—were even more widely skirted by these tangled tidal swamps.

All around, and apparently all over the many islets that darkly dotted the shimmering expanse of this shoreland sea—somewhat as is shown in Plate XXVI—grew also, straightway from the tide-line upward, these clustering deep green mangroves, so closely and evenly that they seemed, when seen from afar, like gigantic clumps of box in some inundated olden garden. They grew so loftily, too, that from the level of the channel near even the largest islets, naught of their inner contours could be seen.

The astonishment I felt, then, on penetrating into the interior of the very first encountered of these thicket-bound islets, may be better imagined than described, when, after wading ankle deep in the slimy and muddy shoals, and then alternately clambering and floundering for a long distance among the wide-reaching interlocked roots of the mangroves—held hip-high above the green weedy tide-wash by myriad

ruddy fingers, bended like the legs of centipedes—I dimly beheld, in the sombre depths of this sunless jungle of the waters, a long, nearly straight, but ruinous embankment of piled-up conch-shells. Beyond it were to be seen—as in the illustration given on Plate XXVII,—other banks, less high, not always regular, but forming a maze of distinct enclosures of various sizes and outlines, nearly all of them open a little at either end or at opposite sides, as if for outlet and inlet.

Threading this zone of boggy bins, and leading in toward a more central point, were here and there open ways like channels. They were formed by parallel ridges of shells, increasing in height toward the interior, until at last they merged into a steep, somewhat extended bench, also of shells, and flat on the top like a platform. Here, of course, at the foot of the platform, the channel ended, in a slightly broadened cove like a landing place; but a graded depression or pathway ascended from it and crossed this bench or platform, leading to, and in turn climbing over, or rather through, another and higher platform a slight distance beyond. In places off to the side on either hand were still more of these platforms, rising terrace-like, but very irregularly, from the enclosures below to the foundations of great, level-topped mounds, which, like worn-out, elongated and truncated pyramids, loftily and imposingly crowned the whole, some of them to a height of nearly thirty feet above the encircling sea.

All this was not by any means plain at first. Except for mere patches a few feet in width, here and there along the steepest slopes, these elevations, and especially the terraces and platforms above the first series, were almost completely shrouded from view under not only a stunted forest of mulberry, papaya, mastich, iron-wood, button-wood, laurel, live oak and other gnarly kinds of trees, mostly evergreen, and all overrun and bound fast together from top to bottom by leafy, tough and thorny vines, and thong-like clinging creepers, but also by a rank tangle below, of grasses, weeds, brambles, cacti, bristling Spanish bayonets and huge spike-leaved century plants, their tall sere flower stalks of former years standing bare and aslant, like spars of storm-beached shipping above this tumultuous sea of verdure.

The utmost heights were, in places, freer; but even there, grew weeds and creepers and bushes, not a few, and overtopping them all, some of the most fantastic of trees—the trees *par excellence* of the heights of these ancient keys, the so-called gumbo limbos or West Indian birches—bare, skinny, livid, monstrous and crooked of limb, and, compared with surrounding growth, gigantic. To the topmost branches of these weird-looking trees, brilliant red grosbeaks came and went as I climbed. Long ere I saw them, I could hear them trilling, in plaintive flute-like strains, to mates in far-away trees, perhaps on other groups of mounds—whence at least answers like faint echoes of these nearer songs came lonesomely calling back as though across void hollows.

The bare patches along the ascents to the mounds were, like the

ridges below, built up wholly of shells, great conch-shells chiefly, blackened by exposure for ages; and ringing like thin potsherds when disturbed even by the light feet of the raccoons and little dusky brown rabbits that now and then scuttled across them from covert to covert and that seemed to be, with the ever-present grosbeaks above, and with many lizards and some few rattlesnakes and other reptiles below, the principal dwellers on these lonely keys—if swarming insects may be left unnamed!

But everywhere else it was necessary to cut and tear the way step by step. Wherever thus revealed, the surface below, like the bare spaces themselves, proved to be also of shells, smaller or much broken on the levels and gentler slopes, and mingled with scant black mold on the wider terraces, as though these had been formed with a view to cultivation and supplied with soil from the rich muck beds below. Here also occurred occasional potsherds and many worn valves of gigantic clams and whorls of huge univalves that appeared to have been used as hoes and picks or other digging tools, and this again suggested the idea that at least the wider terraces—many of which proved to be not level, but filled with basin-shaped depressions or bordered by retaining walls—had been used as garden plats, some, perhaps, as drainage basins. But the margins of these, whether raised or not, and the edges of even the lesser terraces, the sides of the graded ways leading up to or through them, and especially the slopes of the greater mounds, were all of unmixed shell, in which, as on the barren patches, enormous nearly equal-sized whelks or conch-shells prevailed.

Such various features, seen one by one, impressed me more and more forcibly, as indicating general design—a structural origin of at least the enormous accumulations of shell I was so slowly and painfully traversing, if not, indeed, of the entire key or islet. Still, my mind was not, perhaps, wholly disabused of the prevalent opinion that these and like accumulations on capes of the neighboring mainland were primarily stupendous shell heaps, chiefly the undistributed refuse remaining from ages of intermittent aboriginal occupation, until I had scaled the topmost of the platforms. Then I could see that the vast pile on which I stood, and of which the terraces I had climbed were, in a sense, irregular stages, formed in reality a single, prodigious elbow-shaped foundation, crowned at its bend by a definite group of lofty, narrow and elongated mounds, that stretched fan-like across its summit like the thumb and four fingers of a mighty outspread hand. Beyond, moreover, were other great foundations, bearing aloft still other groups of mounds, their declivities thickly overgrown, but their summits betokened by the bare branches of gumbo limbos, whence had come, no doubt, the lone-sounding songs of the grosbeaks. They stood, these other foundations, like the sundered ramparts of some vast and ruined fortress along one side and across the farther end of a deep open space or quadrangular court more than an acre in extent, level and as closely covered with mangroves and

other tidal growths at the bottom as were the outer swamps. It was apparent that this had actually been a central court of some kind, had probably been formed as an open lagoon by the gradual upbuilding on attol-like reefs or shoals around deeper water, of these foundations or ramparts as I have called them, from even below tide level to their present imposing height. At any rate they were divided from one another by deep narrow gaps that appeared as though left open between them to serve as channels, and that still, although filled now with peaty deposits and rank vegetation, communicated with the outer swamps, and, in some cases, extended, between parallel banks of shell like those already described, quite through the surrounding enclosures or lesser outer courts, to what had evidently been, ere the universal sand shoals had formed and mangrove swamps had grown, the open sea.

The elevation I had ascended, stood at the northern end and formed one corner of this great inner court, the slope to which from the base of the mounds was unbroken by terraces, and sheer. But like the steepest ascents outside, it was composed of large weather-darkened conch-shells and was comparatively bare of vegetation. Directly down the middle of this wide incline led, from between the two first mounds, a broad sunken pathway, very deep here near the summit, as was the opposite and similarly graded way I had in part followed up, but gradually diminishing in depth as it approached the bottom, in such manner as to rènder much gentler the descent to the edge of the swamp. Here numerous pierced busycon shells lay strewn about and others could be seen protruding from the marginal muck. A glance sufficed to show that they had all been designed for tool heads, hafted similarly, but used for quite various purposes. The long columnellæ of some were battered as if they had once been employed as hammers or picks, while others were sharpened to chisel or gouge-like points and edges. Here, too, sherds of pottery were much more abundant than even on the upper terraces. This struck me as especially significant, and I ventured forth a little way over the yielding quagmire and dug between the sprawling mangrove fingers as deeply as I could with only a stick, into the water-soaked muck. Similarly worked shells and sherds of pottery, intermingled with charcoal and bones, were thus revealed. These were surprisingly fresh, not as though washed into the place from above, but as though they had fallen and lodged where I found them, and had been covered with water ever since.

I suddenly realized that the place, although a central rather than a marginal court or filled-up bayou, was nevertheless similar in general character to the one Col. Durnford had described, and that thus soon my conclusions relative to the typical nature of the Collier deposit, were, in a measure, borne out. Here at least had been a water-court, around the margins of which, it would seem, places of abode whence these remains had been derived—houses rather than landings—had clustered, ere it became choked with *débris* and vegetal growth ; or else it was a

veritable haven of ancient wharves and pile-dwellings, safe alike from tidal wave and hurricane within these gigantic ramparts of shell, where, through the channel gateways to the sea, canoes might readily come and go.

It occurred to me, as I made my way through one of these now filled-up channels, that the enclosures they passed were probably other courts —marginal, but artificial bayous, some of them no doubt like the one at Key Marco—and that perhaps the largest of them had not only been inhabited also, but that some were representative of incipient stages in the formation of platforms or terraces, and within these, as the key was thus extended, of other such inner courts as the one I have here described. It seemed reasonable to expect that the islets visible in numbers farther on, which my skipper described as almost exactly like this, would really prove to be not only shell keys, that is, of artificial origin, but also, that in them I would find the essential structural features of this one, as such, repeated.

Possessed by this idea, I became doubly anxious to proceed with the explorations, and forthwith returned to the boat and sailed down to a point about midway between the northern and southern ends of Pine Island, which lay some two and a half miles off to the eastward. There stood, near where we anchored, upon rough and barnacle-encrusted stilts or piles, two dilapidated platforms, placed end to end, but at an angle to one another. Upon these were perched a couple of old and weather-beaten huts which had been formerly used, I was told, as fishermen's stations.

As evening fell and the tide went down, there appeared with startling suddenness, black, in the foam of the receding waters,—much as in the illustration on Plate XXVI,—the scattered crags of two or three series of parallel and concentric oyster reefs or bars. Some of them reached directly toward us from close to the old fishing stations, while others extended off to the right, semi-circularly around us, in a long succession of level, broken masses, thus enclosing quite half an acre of deeper water, at the entrance of which we lay. It was in the shallows, between the widest of these bars, at the corner or blunt angle formed by the two main lines of the reefs, that the platforms stood. Hither now flocked hundreds of cormorants and pelicans, followed by a few cranes and curlews and by many gulls—these continually on the wing. But the cormorants and pelicans settled on the platforms and along the uniform inner edges of the reefs in close ranks. They seemed to have come hither from the neighboring bird-keys or mangrove rookeries,—where they nested in common by thousands,—simply to rest and dress their plumage; until, out in the channel appeared, swiftly rushing in toward the shoals, an enormous school of fish, fleeing noisily before several puffing porpoises and two or three monster sharks, whose sharp dorsal fins cut the water swiftly hither and thither in the wake of their affrighted prey. Then of a sudden the cormorants and many of the pelicans took wing, joined forces behind the on-coming fugitive hosts

of the sea, and diving down in a great semi-circle, beat the waves with their wings as though in play, until, as they closed in rapidly toward the reefs, the sound made by them and the now wildly leaping fish was as that of an approaching storm. Thus thousands of the smaller fish were driven in beyond reach of the sharks and porpoises over the shoals and into the bayous formed by the succession of reefs, and there cormorants and pelicans alike made short work of securing their evening meals. The cormorants flew off singly or in swift irregular companies, but the pelicans marched more deliberately away, in orderly and single aëreal files, so to say, behind heavy-winged, gray-headed old leaders, evenly, just over the line of the waves, to their tree-built island homes.

I have dwelt on this singular behavior of the birds because, in connection with the observations of the day, and with the picture formed by the concentric reefs, the lagoon they encircled, the old half-ruined pile-houses standing above them out there in the midst of the waters, and the distant dark-green islands—which I now knew had been the homes of sea-dwelling men centuries before—disappearing beyond in the dusk, it all suggested to me in a vivid and impressive manner how the ancient builders of the key I had only this afternoon reconnoitred had probably begun their citadel of the sea and why there, so far away from the shore, they had elected to make so laboriously their homes; why they had from the beginning kept free within their reef-raised sea-walls of shell, the central half-natural lagoons or lake-courts, where the first few of their stilted houses had doubtless been planted, and why ever, as their hand-made island extended, they had kept it surrounded with the many channeled enclosures. The key had been, so to say, the rookery, the channels and lesser enclosures the fish-drives and fish-pools of these human pelicans! Like the pelicans, like even the modern fishermen, they had at first merely resorted to low outlying reefs in these shallow seas as fishing grounds, but ere long had built stations there, little shelters, probably, on narrow platforms held up by clumsy piles, but similar somewhat to the huts that stood here before me. The shells of the mollusks they had gathered for food had naturally been cast down beside these lengthy platforms, until they formed long ridges that broke the force of the waves when storms swept by. Thus, I fancied, these first builders of the keys had been taught how to construct with special purpose sea-walls of gathered shells, how to extend the arms of the reefs, and to make other and better bayous or fish-pounds within them by forming successive enclosures, ever keeping free channels throughout for the driving in of the fish and the passage of their canoes. And when the innermost of the enclosures became choked by drift and other *débris* they had filled them with shell stuff and mud from the surrounding sea, and so of some had made drainage-basins to catch rain for drinking water, and of others, in time, little garden plats or fields.

Thus it was that the erstwhile stations had become better and better fitted as places of longer abode; and yet others of the enclosures or

courts farthest in had become filled, and were in turn wrought into basins and gardens to replace the first that had been made; for these were now covered over and piled higher to form wide benches whereupon the long mounds or foundations might be erected. Finally, aloft on these greater elevations strong citadels of refuge alike from foe and hurricane; storehouses, dwellings of chiefs or leaders, and assembly-places and temples had been builded, when at last these old people of the sea came to abide there continually. This to me appeared to have been the history in brief of the first development of such a phase of life as the ancient key I had examined that afternoon still plainly represented; nor did I find reason later to greatly modify these views. On the contrary, of the many other shell keys that I examined during the following few days, all still further illustrated, and some seemed strikingly to confirm, even the most fanciful of these visions.

This was especially true of three keys which I explored the next day. The first was known as Josselyn's Key. It had been cleared and cultivated as a fruit and vegetable garden many years before, but was now abandoned and desolate and again overrun by brambles and weeds and vines, with some few massive gumbo limbos and rubber trees standing on its heights. The feature of special interest in this key was its central court, which, while comparatively small—less than half an acre in extent—was remarkably regular. Five very high and steep, mound-capped elevations, sharply divided by deep, straight channels, that led forth from the court divergingly toward the sea, formed its western side and southern end, while its opposite side and end were formed by two extensive platforms, also exceedingly steep within, and nearly as high as the elevations, and divided from these and from each other by straight canals that led forth in northwardly directions, far out through the mangrove-covered enclosures down toward which the platforms were terraced.

The court was very deep and so regular that it resembled the cellar of an enormous elongated square house. It was marshy and overgrown by cane-brakes, tall grasses, and green-barked willows. Near the mouth of the principal canal, leading forth from the southeastern corner of this court, and still invaded, as were two or three others of the canals, by high-tide water, my skipper and I dug a deep square hole. The excavation rapidly filled with water; not, however, before we had found in the yielding muck a shapely plummet or pendant of coral-stone and two others of shell, many sherds of pottery, worked bones, charcoal, and, more significant than all, a pierced conch-shell, still containing a portion of its rotten wooden handle. Again here, the relics were more abundant than on the heights above, and the structural nature of the entire key was abundantly evident.

From this place it was somewhat more than a mile, still east-southeastwardly, to the second islet, which was known as Demorey's Key. It also had been cleared to a limited extent, by the man whose name it

bore, but, like the first, had long been abandoned and was even more overgrown by vine-smothered trees and brambles—among them many pitiful limes and a few pomegranates run wild, but still faithfully bearing fruit—so that here, too, the knife was constantly requisite.

It was in some respects the most remarkable key encountered during the entire reconnaissance. Its elevations formed—as may be seen by reference to plan and elevation on Plate XXVIII,—an elongated curve five hundred yards in length, the northward extension of which was nearly straight, the southward extension bending around like a hook to the southeast and east, and embracing within its ample circuit a wide swamp thickly overgrown with high mangroves, which also narrowly fringed the outer shore, so that the whole key, when seen from the water, presented the appearance of a trim round or oval, and thickly wooded island. The lower end or point of this key consisted of an imposingly massive and symmetrical sea wall, of conch-shells chiefly, ten or twelve feet high, and as level and broad on top as a turnpike. This wall had evidently once encircled the entire lower bend of the key, but was now merged in the second and third of a series of broad, comparatively level terraces, that rose one above the other within it, from a little terminal muck-court, westwardly to the central and widest, although not highest, elevation of the key, at the commencement of its northward extension. Occupying a point midway along the inner curve of this elevation, that is, directly up from the mangrove swamp it encircled on the one hand, and from the terraces outside on the other, stood a lofty group of five elongated mounds. These mounds were divided from the embracing terraces by a long, deep, and very regularly graded way, which led, in straight sections corresponding to the inner margins of the first three successive terraces, up from a canal formed by shell banks or ridges in the swamp, to the highest of the terraces—the one forming the wide central elevation. Another and much steeper and shorter graded way led up from yet another parallel canal farther within the swamp, to between the two highest mounds, down from them again, and joined this longer graded way near the point of its ascent to the high central terrace. This foundation, for it proved to be such, arose very steeply from the here sharply curved edge of the mangrove swamp, to an almost uniform height of about twenty-three feet; was from twelve to fourteen yards wide, and thence sloped more gently toward the outer or western shores. The northern extension of the key was occupied by two or three elevated and comparatively inconsiderable mounds, beyond which it was terraced off toward the extreme point, as was the lower point—though less regularly—to a short, similar sea-wall extension eastwardly, that partly enclosed, not a muck-court, but a low, bordered garden-plat, containing two or three round sinks or basins.

The most remarkable feature of this key was a flat, elongated bench, or truncated pyramid, that crowned the middle elevation. I discovered this merely by accident. In order to gain a general idea of the key,

which was almost as much overgrown with luxuriant and forbidding vegetation as had been the wilder key first explored, I climbed high up among the skinny and crooked limbs of a gigantic gumbo limbo that grew directly from the inner edge of this elevation. Luckily, great festoons of tough vines clung to the lower limbs of this tree, for in shifting my position I slipped and fell, and was caught by these vines, to the salvation of my bones probably, since by the force of the fall some of the vines were torn away, revealing the inner side of this platform and the fact that it was almost vertically faced up with conch-shells; their larger, truncated and spiral ends, laid outward and in courses so regular, that the effect was as of a mural mosaic of volutes. I hastily tore away more of the vines, and found that this faced-up edge of the platform extended many feet in either direction from the old gumbo limbo. I may say here, that on occasion of two later visits I cleared the façade of this primitive example of shell architecture still more; was enabled, indeed, when I last visited the place—since I was then accompanied by a considerable force of workmen—to entirely expose its inner side and its southern end. Thus was revealed—even more completely than is shown in Plate XXIX,—a parallelogrammic and level platform, some three and a half feet high and twelve yards in width, by nearly thrice as many in length. It was approached from the inner side by a graded way that led obliquely along the curved ascent up from the mangrove swamp, to a little step-like, subsidiary platform half as high and some twelve feet square, which joined it at right angles, just beyond the point shown at the extreme right of the picture here given. The top of this lesser step, and the approaches to either side of it, were paved with very large, uniform-sized clam-shells, laid convex sides upward, and as closely and regularly as tiles. The lower or southern end of the main platform was rounded at the corners, and rounded also on either side of the sunken ascent midway, in which the longer of the graded ways I have described terminated. Contemplating the regularity of this work, its central position, and its evident importance as indicated by the several graded ways leading to it from distant points, I could not doubt that it had formed the foundation of an imposing temple-structure, and this idea was further carried out by the presence at its northern end of two small, but quite prominent altar-like mounds.

Descending from the end of the platform down along the main graded way—the one which divided the terraces from the central group of high mounds—I found that at more than one point, the sides of this deep, regular path, had also been faced up with conch-shells, though none of the courses were now, to any extent, in place.

At the foot of the inner and parallel sided, sunken or graded way—the one descending from between two of the great central mounds—I caused an excavation to be made between the two straight banks or ridges of shell that extended thence far out into the mangrove swamp, in order to ascertain whether this supposed canal had really been such; that is,

an open way or channel to the sea for canoes. It became evident that it had been this, for we were able to excavate through vegetal muck and other accumulated *débris* to a depth of more than four feet, although much inconvenienced by inflowing water. I thus found that the shell-banks had not only been built up with a considerable degree of regularity, but that, well defined as these ridges were, the portions of them visible above the muck were merely their crests. The excavation was made near what may thus be regarded as having formed the original landing, and in it we found a considerable number of quite well-preserved relics, similar to those I had found in the court on Josselyn's key. Another excavation made near the termination of the two embankments, however, revealed fewer artificial remains, other than blackened and water-worn sherds of pottery. But I found that here also, the artificial banks or walls, so to call them, had been built up with equal regularity, almost vertically, from a depth of between four and five feet. In extending this excavation, an interesting feature of the original foundations of these outworks was revealed. It consisted of a kind of shell breccia formed of the first layers of shells that had been placed there—that were composed of conchs, some of which had been driven or wedged, smaller ends first, into the original reef or bar, and had apparently been further solidified by a filling or packing in of tough clay-like marl, now so indurated that shell, sherds of pottery, and here and there bits of bone and charcoal formed, with it, a solid mass well progressed toward fossilization. Indeed, when large fragments of this time-hardened cement were pried up and broken open, the shell, sherds of pottery and bones contained in them appeared already like fossils. I found by making yet other excavations in the contiguous and almost untraceable courts or enclosures, that they, too, had been built up from an equal depth, as though to serve rather as fish-pounds than as breakwaters or as courts to the quays and houses, for the crests of these enclosures so slightly protruded above the surface of the muck and weedy carpeting of the mangrove swamp in which they occurred, that I had at first quite failed to observe them. Thus it appeared that this half-enclosed swamp, no less than the swamps surrounding the first key I had examined, contained similar sorts of enclosures, only these had been lower originally, or else had since been more filled in with muck, vegetal growth and tide-wash. The low-bordered terrace or garden plot, the margin of which faced this swamp within the northern end of the key, was wide and comparatively level, except that in one or two places toward the slopes of the terraces next above it, there occurred in it the circular holes I have mentioned as basins, one of which looked almost like a well. The like of these I later encountered on many others of the keys, and they seemed to be catch-basins for rain or places for water storage, artificial çenotes, as it were, like the spring-holes or sink-holes on the mainland and in Yucatan. Moreover, the surrounding plot, like the terraces at the lower end of the key, and like those I had found on the first island I had explored, was scantily supplied with

black soil intermixed with the shells, and here I observed that although relics of other sorts were comparatively rare, fish-bones formed a considerable proportion of this soil, as though fish or the refuse of fish had been used here for fertilizing purposes. All these observations, taken in connection with the highly finished condition of the crowning platform, of the beautifully paved approaches to it, of the walls or sides of the long-graded path, and of the terminal sea-walls themselves, clearly demonstrated the artificial origin of not only such portions of the key as stood above low-tide level, but also, the highly structural character of the whole work—as I now considered it to be,—of the island in its entirety.

Visible from Demorey's key, a mile and a half or two miles away in a northeasterly direction, stood a promontory, island-like in appearance, on account of its relative boldness. Learning from my sailor that it was really on Pine Island, and that there also were extensive shell accumulations, and that in the depths of the pine lands beyond were other and larger mounds of quite different character, I paid a hasty visit to the place.

It was known as Battey's Landing, although the "landing" had to be approached by wading a long way, for the tide was low. And as we neared it we were greeted by the barking of a small colony of hounds and other dogs. A solitary man appeared, who occupied one of two small huts that stood some way up from the shore. His name was Kirk, and he was most hospitable and helpful to me. He and his partner, Captain Rhodes, worked the place as a vegetable farm, and were now again most profitably cultivating its ancient gardens. However, I soon saw that it had once been like the outer islets—an artificial key—but so much closer in-shore, even originally, that it had become connected with the main part of Pine Island by extensive sand flats, still so low as to be washed by high tides. The foundations, mounds, courts, graded ways and canals here were greater, and some of them even more regular, than any I had yet seen. On the hither or seaward side many enclosures, overgrown of course by mangroves, flanked wide benches or garden platforms, through or over which led paths, mostly obliterated by cultivation now. The same sorts of channel-ways as occurred on the outer keys led up to the same sorts of terraces and great foundations, with their coronets of gigantic mounds. The inner or central courts were enormous. Nearly level with the swamps on the one hand, and with the sand flats on the other, these muck-beds were sufficiently extensive to serve (having been cleared and drained as far as possible) as rich and ample gardens; and they were framed in, so to say, by quadrangles formed by great shell structures which, foundation terraces, summit-mounds and all, towered above them to a height of more than sixty feet.

There were no fewer than nine of these greater foundations, and within or among them no fewer than five large, more or less rectangular courts; and, beyond all, to the southward, was a long series of lesser benches, courts and enclosures, merging off into scarce visible frag-

ments in the white, bare stretches of sand flats. Suffice it, if I say, that this settlement had an average width of a quarter of a mile, and extended along the shore of Pine Island—that is from north to south—more than three-quarters of a mile; that its high-built portions alone, including of course, the five water courts, covered an area of not less than seventy-five or eighty acres. The inner courts were all, except one, furnished with outlets that had originally opened through short canals into the strait that had separated the key from the main island. The single exception referred to was notable. The midmost of these inner courts, which was too low to be made use of as a garden, and was therefore still overgrown with enormous mangrove, button-wood and other trees, was, or had been, connected with the sea by a canal that led into it between two long, very high shell elevations, which flanked it on either side of the western end. From the opposite end of the court another canal led directly eastward into the pine lands. Not to pause with a further account of this greatest, except one, of all the monuments of the ancient key builders on the Florida coast, save to say that in the court of the canals I found the finest and best preserved relics I had yet discovered, I will only describe this landward canal and the gigantic mounds and other inland works to which it led. It extended in a straight line almost due eastwardly across the sand flats, that were, at this point, very narrow, and heavily overgrown with canebrakes and high grasses; while beyond, palmettos and yuccas covered the entire plain far into the pine-lands. It was uniformly about thirty feet wide, and though of course now much filled, especially between the shell-made levees that crossed the flats, it still maintained an even depth of between five and six feet. A few yards beyond where it entered the higher level of the pine lands, there was a little outlet from its southern side, which led straight to what had been an enormous artificial pond or oval lake, that was still so boggy I could not traverse it. From the opposite end of this lake, in turn, led for nearly a quarter of a mile further, in a generally southeastern direction, but not in a straight line, another and lesser canal. It terminated in another artificial lake, that extended east and west, and in the middle of this stood, crosswise, a gigantic and shapely mound. This mound was oval in outline, fifty-eight feet high, some three hundred and seventy-five feet in length and a little more than one hundred and fifty feet in the width at its base. A graded way wound around it spirally from the southern base to the summit, which was comparatively narrow, but long and level like the tops of the shell mounds on the keys. Ascending this mound, I found that it had been built up of sand and thin strata of sea-shells alternately, and that to the presence of these strata of shells had been due, probably, the remarkable preservation of its form. Potsherds of fine quality, chalky remains of human bones, broken shell ladles—their bottoms significantly punctured—all demontrated the fact that this mound, which obviously had been used as the foundation of a temple structure, had also served as a place of burial.

Due northeast from it, half a mile farther in, might be seen another and even larger mound, double, not single-crested, like this. The great canal, a branch of which opened into the encircling lake of this mound also, led on directly past it, and could be plainly traced, even from this distance, through the palmetto-covered plain beyond. Again, in a southwest direction, not quite so far away, I could discern among the scattered pines a hummock, comparatively low and small, but regular and overgrown thickly with palmettos and brambles. It, too, proved to be a mound, mostly of shell, but probably built for burial purposes, yet furnished like these two larger ones, with a contiguous lake or pond hole, from which also led a slight canal to the near-by sand flats. Returning to the greater canal and following it out to the point of its connection with the lake of the double mound, I found that the eastern end of this lake was large, rather square than round, and that it formed really a water-court fronting the mound and more or less surrounded originally with embankments—of sand chiefly—but like the characteristic shell embankments of the keys in form, as if, indeed, made purposely to resemble them. From this excavated lake-court, a graded way had also once led up the eastern side of the double mound, its terminus forming, in fact, the saddle between its two summits—that reached an altitude of more than sixty-three feet. In all these regards it exactly resembled one of the great shell foundations—crowning mounds and all—of the outer keys, and I could not but be impressed with the apparent significance of this, especially as I found by slight excavation that the mound had been composed, like the other, of shell strata in part, and that it was erected veritably as a foundation, since there was no evidence that it had been used to any great extent as a burial place. Moreover, the great canal, turning a little to the southeast, led on again in a straight line into the interior. I followed it for more than a mile, and, although it lessened in width, it was distinctly traceable still beyond, and I was told that it extended quite across the island to similar works and shell elevations on the other side. I later learned that the canal and mounds on Naples Island were not unlike these, although smaller, and that equally gigantic works occurred far up the great rivers of the coast, as far up the Caloosahatchee, for instance, as Lake Okeechobee and the Everglades. Everywhere, too, these inland works resembled, with their surroundings—embankments, court or bayou-like lakes, canals, graded ways, etc —the works of the keys. And I have been led to infer that they actually represent the first stage of a later and inland phase of key-dweller modes of building, and furnish a hint that, perhaps not only other inland mounds of Florida, but also the great and regular mounds and other earth-works occurring in the lowlands of our Southern and Middle Western States, and celebrated as the remains of the so-called mound-builders, may likewise also be traced, if not to this beginning, at least to a similar beginning in some seashore and marshland environment. I shall therefore recur to the subject specifically in later paragraphs.

Immediately after completing this examination of what I regarded as one of the most recent and highly developed works of the ancient key-builders, I proceeded down the Sound to St. James City, at the southern end of Pine Island. Fortunately I bore friendly letters of introduction from Colonel J. M. Kreamer, of Philadelphia, to Captain E. Whiteside, the principal resident of the little city. He welcomed me most hospitably, and extended to me whatever help it was possible for him to give.

Curiously enough, the three or four places next examined by me after my arrival at St. James City, were as illustrative of the *beginnings* of the key-dweller modes of life as had been the remains I had last explored, of their later development.

At the extreme southeastern point of Pine Island occurred the first of these. It consisted chiefly of a single long and, throughout the lower portions of its course, double-crested shell embankment, from four to nine feet high. I was at once struck by the fact that this great shell ridge, which was more than thirty-five hundred feet in length, was made up in parts, or comparatively short, straight sections, placed end to end, so that its general contour was more or less polygonal, for it partially encircled a wide mangrove swamp on its inner or landward side, within which could be faintly seen here and there low shell-bank enclosures such as I have so frequently described heretofore. I have said that this shell ridge was in some places double, or rather double-crested. These double or parallel crests along its summit were here and there still so sharp that they distinctly appeared to have been formed by deposition from above. This suggested to me that in the beginning, a series of straight, narrow platforms or scaffolds had been erected end to end over the curved outlying reef here, and that shells—perhaps mere refuse at first, precisely as I had imagined when looking at the old Fishing Station, above—had been cast down along either side of these platforms until a nucleus of the ridge was thus formed. At two points, however, the works had been widened and more regularly built up, as though at these points the beginnings of characteristic terraces and of at least one foundation had been made. But nowhere else was there evidence that this ancient structure had progressed much beyond its earliest, its fishing-station-stage of construction. It appeared to me that ere it had been possible for the ancient builders to carry their work here further towards making a permanent home, some hurricane or great tidal wave had overwhelmed them, or had so far destroyed their station or incipient settlement as to render its further completion undesirable or impossible; and that thus we had preserved to us in this place an evidence of their modes of beginning such stations or settlements. Again, at the opposite or southwestern point or corner of Pine Island had stood another great shell ridge, higher, wider, generally curved also, and a little further progressed towards formation as a permanent settlement; for at its upper end there remained evidence that it

had possessed narrow terraces and two or three considerable foundations. The greater portion of this work, however, had been removed by Captain Whiteside—at a cost of more than ten thousand dollars—for use in the construction of a boulevard around the end of the island and of crossroads through the marshy space it enclosed. Miles of shell-road—the most beautiful in southwestern Florida—had thus been made, yet still the shell material of this one old-time beginning merely, of a key, had not thereby been wholly exhausted. Few relics, other than a couple of skeletons and numerous shreds of pottery and fragments of broken shell tools, had been encountered during the demolition of the structure; yet it was plain that it had been built on low encircling reefs up from the very level of the water as had all the others.

Another work, quite similar to this, but still undisturbed, was found by me straight across Carlos Bay,—as the body of water to the south and west of Pine Island and at the mouth of the Caloosahatchee river was called—on one of the inner marginal reefs of Sanybel Island, the lower end of which formed here a great loop around the bay and entrance referred to. At this point the ancient key-builders had succeeded in progressing a stage or two further in the construction of one of their settlements ere they had been, evidently in like manner as at the other places, overwhelmed by some catastrophe. Such portions of the work as were left—for some part of it had been destroyed and washed away by successive storms—formed more of an enclosure of mangrove swamp than did either of those last described. It had been considerably widened and built up, at its middle, and again towards its western end. Well-defined canals led in from among shell-bank enclosures within the mangrove swamp to both of these built-up points, the westernmost terminating in a diminutive inner court. At both points, too, the foundations of mound-terraces had been begun. Digging in towards the middle of one of these incipient terraces from the outer shore line, I encountered not only numerous relics, but also large, flat fragments of breccia-like cement. Further up, on the more level portion of this terrace, I found that the cement was continuous over a considerable space, but that the bed thus formed abruptly ended along a line parallel with the western edge or end of the elevation. At almost regular intervals along this line occurred holes in the compact substratum of shell, formed by the decaying of stout posts that had been set therein—as was shown by lingering traces of rotten wood that occurred in each. Thus it appeared that this flat bed of cement had once formed a thin vertical wall, or rather the plastering of a timber-supported wall, probably the end of some large building which had crowned the terrace, and that had fallen in under the stress of some storm or as a result of other accident.

To ascertain whether the works here were, like the outworks of Demorey's key, originally founded upon a shallow or submerged reef, I caused a trench several feet long to be excavated down to between eighteen inches and two feet below mean tide-level. I thus ascertained

that here, as on Demorey's key, the whole structure had, indeed, been built up on a shoal or reef; a solid foundation of very large conch-shells having first been driven into the original reef, but not apparently here reinforced with clay-marl; smaller shells of many kinds having then, in turn, been piled on this, and that finally—as shown by the talus of uniform-sized conchs around the base of the terrace—the outer and inner faces of the whole elevation had been covered over or faced up with courses of these beautiful shells. The examination of the mere beginning of a station or a settlement at the southern end of Pine Island, then of this further advanced remnant of ancient work, demonstrated to me the correctness of the inference I ventured, prematurely perhaps, to mention in an earlier portion of this paper. The finding here, also, of what was almost unmistakably the outer coating or plastering of a temple or some other kind of large building upon one of the flat terraces or mounds, such as I have so often described as found on the upper keys in more perfected condition, seemed also to indicate as unmistakably that these mounds, wherever found, had been designed as the foundations of such buildings of a more or less permanent and probably public or tribal character.

A long, very low sand-spit, comparatively narrow, and covered with mangroves, extended in a direction parallel with the curved inner shores of Sanybel Island, from very near the end of this ancient settlement to almost the end of the island itself. This low bar, joined by another that put out from the oppositely curved shore of the island, enclosed a round body of water known as Ellis' Bay. I heard that Captain Ellis, the long-time resident of the place, had found near his quaint palmetto huts on its southern shore, a few days previously, some human bones. I visited his place. I would fain describe it in all its picturesqueness,—the thatched houses irregularly set on the low flat stretch of sand, amid clumps of native palmettos and luxuriant groves of lime, orange, and other tropical fruit trees; but can only pause to make due acknowledgment of his whole-souled courtesy and helpfulness during the prosecution of my hasty excavations there. Behind his little assemblage of huts, the land rose gradually to a considerable height, consisting almost wholly of sea sand, that had been drifted over from the opposite beaches of the gulf. This sand drift had in the course of centuries quite buried a low but extensive ancient shell settlement. A drainage canal, that had recently been dug by settlers living farther up the island, revealed to me the previously unsuspected presence of this settlement, and the fact that it, like all the others I have described, had been built up originally from reefs or shoals. From it, a sort of causeway of conch-shells had once led out towards a nearly round, enclosed space, closer to the present shore, and off to the westward side of Ellis' place. This enclosure was now, of course, filled with boggy muck and overgrown; but it surrounded a somewhat extensive, low mound, composed in part of shells and in part of black soil. The mound (or hammock, as such mounds in lowlands

are universally called in that section of the country) was under cultivation as a vegetable and fruit garden; and it was in the attempt to remove from it the roots of a large stump, that Captain Ellis had made the find of human bones I had heard of. In excavating near by, I discovered that the whole heap was permeated, so to say, with broken human remains; large bones and small, many of which had been split or shattered, mingled with skulls, some few fortunately still entire, although very fragile. I succeeded in securing eleven of these skulls before leaving. Few relics of any other sort, save now and then punctured shell ladles, were encountered; but it was perfectly obvious that the place had been a true bone-heap, established on a slight artificial elevation in the midst of an ancient enclosed pond or water court, and it was also evident that the human remains therein deposited, had been dismembered before burial, for ceremonial purposes probably—had been even broken up in some cases. I later learned that this place was typical of the ossuaries or lake-enclosed cemetries almost invariably found on the ancient keys, and came to look upon these curious little mortuary lakes or water courts, with their overfilled central islets, as having been thus framed and fashioned to be, as it were, miniature Keys or Shell Settlements of the Dead Key Dwellers buried therein.

I believe I have now described sufficiently typical examples of the ancient artificial shell islands—or, as I like better to call them, "Keys"—of these inland seas of the southwestern coast of Florida.

Ere passing on to the scene of our long continued and more thorough examination of one of the most ancient and characteristic of these, however, it may be well for me to mention that there were, in Charlotte Harbor, Pine Island Sound, Caloosa Entrance and Matlatcha Bay alone, more than seventy-five of them. Forty of this number were gigantic, the rest were representative of various stages in the construction of such villages of the reefs. No doubt a more searching exploration of these waters, and of the wide and forbidding mangrove swamps on contiguous shores of Sanybel, and of others of the outer islands, and of Pine Island, as well as of the mainland itself, would reveal many others; but the amount of work represented even by the number I have already named is so enormous and astounding, that it cannot be realized or appreciated by means of mere spoken description or statement.

Beyond the incurving lower point of Sanybel Island, it was necessary to make the rest of my journey through the open Gulf; not that another series of narrower inland seas did not lie within similar narrow, sandy islands, but because I could not pause to examine their islet-studded reaches. I stopped at only two places on my way to Key Marco, which was still between forty and forty-five miles further to the southward. One was at Mound Key or Johnson's Key, as it was variously called. I make mention of my visit to the place principally because of its great extent. It consisted of a long series of enormous elevations crowned by imposing mounds that reached an average altitude of over sixty feet. They were

interspersed with deep inner courts, and widely surrounded with enclosures that were threaded by broad, far-reaching canals, so that this one key included an area of quite two hundred acres, within which area may be reckoned only such surface as had been actually reclaimed by the ancient key builders from this inland or shore-land sea. I was told by Mrs. Johnson, wife of the owner of the place, to whom good Mrs. Ellis had kindly given me a characteristic letter of introduction, that burial mounds, not unlike the one on the Ellis place, but larger, occurred in the depths of the wide mangrove swamps that lay below towards the mainland, and that here on the heights, many Spanish relics had been found—Venetian beads, scraps of sheet copper, small ornaments of gold and silver, and a copper-gilt locket. She showed me this. It contained a faded portrait, and a still more faded letter, written on yellow parchment, apparently from some Spanish Grandee of about two hundred years ago to a resident colonist of that time.

Whether these relics indicated that here the ancient key dwellers or their mixed descendants had lingered on into early historic times, and that the Mission that these things betokened, had been established among them, or among alien successors, could not, of course, be determined; but around the lower courts, and on the old garden terraces, I found abundant specimens of shell and coarse pottery, characteristic of the key dwellers proper who had anciently built this island, and since returning I have carefully examined an interesting series of both kinds of relics gathered here by your fellow-member, Mr. Joseph Wilcox, which offer even better evidence of this, and are now I am happy to say preserved in the University museum.

I made only a brief stop at Naples City. Captain Large of that place, to whom I bore a letter of introduction, received me most courteously, and showed me, nearby, the mouth of the ancient canal, of which I had already heard from Col. Durnford. Except that it once opened in directly from the Gulf and had evidently been designed as a canoe pass across the island, it was in many respects like the one I had examined on Pine Island, although deeper and at the same time narrower. I was told by Captain Large that like mounds, too, occurred near its outlet on the farther side, and that it terminated in front of some ancient shell works out in the inner bay beyond, similar, I judged, to those at Battey's Landing.

From Naples City the sail to Marco was short; for squalls were rising out over the Gulf, making its opalescent waters tumultuous and magnificent, but to my sailors, terrible, driving us now and anon furiously fast through the rising billows, what though our sails were reefed low. Big Marco Pass opened tortuously between two islands of sand; the northern one narrow, long and straight, backed by mangrove swamps; the southern one broad, generally flat but undulating, and covered with tall, lank grasses, scattered, scrubby trees, and stately palmettos. The mangrove swamps, sundered by numerous inlets on the one side, this

wide, straight-edged sandy island on the other, bordered the inlet that led straight eastward a mile or more to the majestic cocoanut grove that fronted Collier's Bay and Key Marco. I will not describe the key greatly in detail, for an admirable contour map of it, made with great care by Mr. Wells M. Sawyer, artist of the expedition I later conducted to the place, is furnished herewith. The key, like Battey's Landing, like Johnson's key, and many other places of the kind, was now more or less connected with contiguous land; yet obviously, when built and occupied, it had stood out in the open waters. It was not even yet joined to Caximbas Island, at the northwestern angle of which it stood, save by a wide and long mangrove swamp that was still washed daily by high tide. As may be seen by the plan,—on Plate XXX,—a number of long, straight and narrow canals, terminating in little court-like landings and short graded ways, stretched in from the western side, the lower end of which was enclosed and extended by a massive, level-topped sea-wall, now used as a wagon road, reaching nearly a quarter of a mile into the mangrove swamps, and indicating that when it was built, this had been the stormward side, which it had therefore been necessary to protect. There were other indications that the extensive sand bank or island which now fronted the key across Collier's Bay on this gulf-ward side, as well as the long reaches of mangrove swamp to the southward, had all been formed, in the main, since the date of its occupancy. This was notably the case with many other keys in the neighborhood of Key Marco, which keys formed, with the intermediate mangrove islets,—mere segregated sections of swamp they appeared, scarcely rising above the tide level,—the northernmost of the great archipelago of the Ten Thousand Islands. Explorations among these border islands, within a radius of from fifteen to twenty miles around Key Marco, demonstrated the fact that on an average about one in every five of them was an ancient shell settlement or key proper like Marco and the others already described, and that the low-lying intermediate islets had mostly been formed on shoals caused by drift, around and between these obstructions built by man, since the time of their occupation. Again, around each one of these more southerly shell keys or settlements, the fringe of the mangrove swamps was far deeper, or wider, than around the more northerly keys, indicating that a much greater time had elapsed since their abandonment; time enough for the formation of many miles of sand bank, and the growth thereon of the mangrove swamps around and between them. Marco inlet, or the eastward and southward extension of Big Marco Pass, formed to the northeast and east of Key Marco a comparatively wide, deep bay. The edge of the key along this bay had evidently been worn away to some extent, so that its eastern face afforded in places sectional views of its structure that told the same story with regard to this key that my excavations had told with regard to Demorey's and the little keys in the neighborhood of St. James City;

namely, that although far more extensive and quite lofty, this, no less than they, had been built from the very sea level upward. Two or three straight, deep and regular canals led in from this side also, one in particular, directly through the loftier terraces here, to the central elevation of the place. This reached a height of only eighteen or nineteen feet, yet it was still remarkably regular, nearly parallelogrammic, flat-topped, and upon its level summit stood—in place, probably, of the ancient temple that once surmounted it (for there occurred here, as on the pyramid-platform of Demorey's key, an altar-like mound near the northern end)—the house now occupied by Captain Cuthbert, partowner, with Captain Collier, of Key Marco. A graded way descended slantingly across the lower end of this eminence, into what had first been a central court, like the one on Josselyn's key. This, however, had in course of time been filled purposely, and the canal that had led straight into it from the south had been filled in too, so as to form a prolongation of the graded way down to the edge of the great court or muck-filled bayou that was embraced within the two lateral and southern extensions of the key. In the southeastern portion of these broad flat canal-seamed extensions, might be seen still two or three remarkably regular and deep circular tanks or çenotes, as I have called them, whence straight sunken ways led up to the easternmost of the series of broad foundations and mounds that, with other filled-in garden courts between, flanked the central eminence or temple-pyramid on either side. Just inside of the sea wall that protected the southwestern edge of the key occurred the little triangular muck-court which had been dug into first by Captain Collier, Mr. Wilkins, and Colonel Durnford.

I was most courteously received by Captain Collier; both he and his neighbor, Captain Cuthbert, gave me entire freedom to explore wheresoever I would, and in whatsoever manner. As may be seen by the accompanying plan of the "Court of the Pile Dwellers," (thus I later named this place) I caused an excavation to be made to one side of and just beyond those that had been made by the gentlemen mentioned (see plan, Plate XXXI, Sections 34, 44). A single day's work in this boggy, mangrove-covered, water-soaked, muck and peat bed, revealed not only other such relics as I had found in the keys above, but a considerable number of well-preserved objects of wood, including more of the kind I had seen in Colonel Durnford's possession, and, what was especially significant, the remains of short piles, of slight timbers, of a long, beautifully finished spruce-wood spar, of charcoal, and fragments of indurated material that had once formed the heat-hardened plaster of hearths. There were also small masses of much decayed thatch, apparently for house-roofing or siding, I judged, and not a few unfinished objects, to say nothing of abundant refuse of meals. All which indicated that my inference in regard to the nature of this place as an actual site of former residence was as tenable as had been the more general conclusion that it was not a solitary

example of its kind. Key Marco, water-courts, canals, elevations, central mounds, cistern holes, garden terraces and all, was, that is, but another such as were the keys further north. I scarcely paused in this preliminary reconnaissance to do more than determine this most significant point, but prosecuted the excavation only during a portion of the following day, then packed up my already considerable collection, and securing permission from Captain Collier, to bring men and more thoroughly excavate the place another year, returned to St. James City.

There, with Captain Whiteside's ready help, I secured the services of an intelligent and interested Scotchman, Alexander Montgomery by name, and of Johnny Smith, an active and bright young pilot of the place. With them, I reëxamined and excavated to some extent, in the keys I had already seen, and in some others around Pine Island ; finding only more and more reason to regard them as of such kind as I have already described.

The rainy season had set in. The heat was excessive, although it was only early June. The mosquitoes and sand flies swarmed forth from the mangroves in such clouds that wherever we dug, except on one or two of the comparatively barren and lofty keys, it was necessary for us to build smudge-fires all around us and breathe their pungent smoke in order to be free from these irritating creatures. I mention this, not because I was forced to abandon work thereby, but since it offered one more explanation—an important one, it seemed to me—of the causes that had led to the building and occupation of these ancient keys so far out in the shallow but open waters, where, ere the mangroves grew, men were comparatively free from these pests of life in southern Florida

These additional explorations quite convinced me that in those yet unnumbered tropic islands lay a vast, comparatively new and very promising field for archæological research, and with this thought and its warrant in the way of collections, I hastened back to Philadelphia and made report to Doctor Pepper.

Organization of the Pepper-Hearst Archæological Expedition.

I am happy to say that Dr. Pepper, with the ready aid of several of his friends and associates, immediately planned to fit out under my direction, during the following winter, an expedition for the more complete exploration of this interesting region. At a meeting held soon after my return, Mr. Jacob Disston generously volunteered not only to make a contribution—as did several other Associates of the Archæological Department of the University, whom I would fain mention—but, also, to turn over for our use his schooner, the *Silver Spray*, belonging to a fleet of sponging vessels at Tarpon Springs, some twenty-five miles north of Tampa, on the west coast of Florida. Almost as speedily,

too, Major J. W. Powell, Director of the Bureau of American Ethnology, provisionally granted me leave, and promise of official recognition and assistance in the conduct of this proposed expedition in the joint interest of the Bureau itself, and of the Department of Archæology of the University of Pennsylvania.

Funds were placed at my disposal by Dr. Pepper late in November, 1896, and happily I was able to secure the volunteer services of Mr. Wells M. Sawyer, to be Artist and Photographer of the expedition ; of Mr. Irving Sayford, of Harrisburg, to be its Field Secretary ; and, for a small salary, of Mr. Carl F. W. Bergmann, previously trained as a Preparator of Collections, in the United States National Museum.

The Clyde Line Steamship Company again laid us under obligation by furnishing passes for all of these gentlemen, from New York City to Jacksonville and Sanford. They left Washington on the fourth day of December. Two days later, Mrs. Cushing and I left overland, and joined them at Jacksonville. Without delay we proceeded thence via Sanford, to Tarpon Springs.

Explorations in the Region of Tarpon Springs.

Unfortunately I found that the *Silver Spray* had but recently been sent away on another sponging cruise, and that I could not expect her return for some time. Anxious as I was to proceed with the exploration of the shores and keys further to the southward, nevertheless, it became necessary, in order that time be not lost, to prosecute investigations in the less novel, but still, archæologically rich fields around Tarpon Springs and in the region of the Anclote river,—upon a bayou of which this beautiful little winter resort was situated.

Since Mr. Clarence B. Moore, of this city, has for a number of years conducted, with rare skill and great success, explorations among mounds and the ancient camp sites of other more easterly portions of Florida, and since the collections he has gathered there, more or less resemble those that we were able to gather in the burial mounds and camp sites of the Tarpon Springs region, and have been admirably illustrated to the world in his various monographs, I will, in this paper, pass over the results of our explorations there very lightly.

We met helpful friends at Tarpon Springs. Messrs. Cheyney and Marvin assigned to us comfortable quarters in one of their hotel cottages and subsequently aided us in many ways ; and it was my especial good fortune to meet Mr. Leander T. Safford, adopted son of the founder of Tarpon Springs, and to be conducted by him, on the very day of our arrival, to an ancient burial mound lying at the foot of the village, on land belonging to the Safford Estates. This little mound was low and apparently unimportant, for it had been superficially honeycombed by relic hunters ; yet a few scattered fragments of bone, associated with mortuary potsherds, indicated to me not only that it had been extraordinarily rich in burials, but, also, that in its depths many of

the interments still remained undisturbed. Accordingly I forthwith engaged workmen to excavate it systematically and thoroughly—a labor that occupied several weeks. During its progress, however, we encountered the remains of more than six hundred skeletons. These, with notable exceptions—probably those of chiefs and head men—had been dismembered previously to interment, but were distributed in distinct groups that I regarded as communal or totemic and phratral, and of exceeding interest; for they seemed to indicate that the burial-mound had been regarded by its builders as a tribal settlement, a sort of "Little City of their Dead," and that if so, it might be looked on as still, in a measure, representing the distribution and relations of the clans and phratries in an actual village or tribal settlement of these people when living. Moreover, in the minor disposition of the skeletons that had not been scattered, but had been buried in packs, or else entire and extended, in sherd-lined graves or wooden cists within and around each of these groups, it seemed possible to still trace somewhat of the relative ranks of individuals in these groups, and not a few of the social customs and religious beliefs of the ancient builders. This possibility was still further borne out by the fact that with the skeletal remains were associated, in differing ways, many superb examples of pottery and sacrificial potsherds, and numerous stone, shell and bone utensils, weapons, and ornaments. That the Safford mound was typical was conclusively shown when we were permitted by Captain Hope, of Anclote, to excavate a similar, although larger and higher mound, on land of his at Finley Hammock, some nine miles to the northwestward of Tarpon Springs, and when we found there also, abundant similar interments and relics of like kinds, similarly distributed.

Of all the art remains we recovered from these two mounds, none possessed greater interest than the pottery. Considerable numbers of unusual forms were found, including terra-cotta drums, tall, very ornate cups or vases, and small flat-bottomed bowls, decorated by means of etched and carved lines, some of these carved designs being maskoidal in character, and obviously derived, as were the stamped and otherwise wrought surface designs on countless sherds in the collection, from woodenware forms and designs. By far the most interesting class of this pottery was, however, such of it as had been decorated by punctation—literally by tattooing—not merely, I judged, in imitation of tattooed totemic designs on the persons of those who had made and used it,—but in an effort to veritably transfer or reproduce these designs; so that in studying them I recognized much in regard to the totemic organization, and still more in relation to the mythic concepts of their makers. I also perceived in these significances and designs, some of which correlated perfectly with those shown on the paintings of Florida Indians given me by my lamented friend, the late Doctor G. Brown Goode, and reproduced from water colors made by the Limner of Laudonnier's Expedition to Florida more than three hundred years ago—

the first clear evidence thus far known to us, of that kind of personification-transfer by means of tattoo or paint, with which primitive artists seem ever to have sought to animate their own particular utensils—food and water vessels especially—and to thus relate them personally to themselves. And I can safely say that a prolonged study of these collections, so strikingly and unusually suggestive in this respect, would throw more light upon primitive decorations, as being in the nature of symbolic investures, not primarily of artistic and æsthetic expression, than any others yet, so far as I am aware, gathered.

There was a feature in connection with these Tarpon Springs and Anclote burial-mounds, that was more specifically significant to me. All of them were surrounded by what at first appeared to be moats. Excavation made it evident, however, that in case of at least the Safford and Hope mounds, these encircling depressions were rather the borders of artificial basins, which had been not only purposely, but also most laboriously, hollowed out, and in the midst of which, it was clear, the mounds had been built, not at once, but in stages, corresponding to successive periods of interment; for they were distinctly stratified, and moreover the remains in the lowermost stratum occurred at a depth greater than that of the muck-filled bottoms of the moat-like depressions surrounding them. This lake-mound kind of burial seemed to indicate survival of key-dweller modes of burial—hence its specific significance to me. That is, I looked upon it as probably being a later, an inland form of bone deposition in an enclosed water-, or lake-court—here imitative, no doubt—such as I had examined at Ellis' Place on Sanybel Island. Moreover, the "Hammocks" or inland shell-heaps or camp-sites, associated with these burial-mounds of the Tarpon Springs and Anclote region likewise possessed key-dweller features; in the earthworks, graded ways, artificial lakes or pond-holes, and canals usually contained within or around them; as though these, in turn, were survivals of or were copied from key-dweller modes of settlement—the works of successors or descendants of the key dwellers following out here in the marshes of the mainland, their characteristic—and erstwhile necessary—modes of building and settlement in the shallow seas. From all this and from evidence of similar survival in art shown abundantly by the collections we gathered from these mounds and camp-sites of the northerly Gulf region, I believed that a bridge, alike in time and in art and cultural development, might be established between the pristine key dwellers of the South, as exemplified by their great shell structures, fish courts, mound terraces, and works in wood and shell, and the historic mound-building Indians not only of northern Florida, but also, possibly even of our nearer Southern States—as pictured by the early chroniclers—who describe them as having been settled in lowland villages clustering around mounds or pyramids of earth that were surmounted by temples and other public buildings, approached by canoe channels and graded ways, provided with fish-ponds or lakes, and with temples of the dead sequestered in nearby deep forests or swamps.

The Cruise to the Ten Thousand Islands and Preliminary Operations at Key Marco.

The *Silver Spray* was tardy in returning, and, withal, had to be overhauled. Thus it was not until late in February that we were able to fully equip her and get under way for the southern keys—explorations in which had been from the beginning, the main object of the Expedition. We were provided with provisions for two months, and with a working outfit which, although the best I could purchase on the west coast of Florida, would have proven all too inadequate but for the kindness of friends before mentioned, and in particular, of a resident of your city and member of your University Archæological Association, Mrs Richard Levis, who, with her friend, Mrs. George Inness, was passing the winter in her charming place at Tarpon Springs, and who insisted on adding needed supplies to our limited store, and little comforts to our else rather barren cabins. We had reason enough to be grateful to them during our long continued stay in the more inaccessible waters of the farther South.

In addition to Mrs. Cushing, myself, and Messrs. Sawyer, Sayford and Bergmann, my crew consisted of Antonio Gomez, Sailing-Master; Thomas Brady, Mate; Alfred Hudson, Robert Clark and Frank Barnes, Sailors and Excavators; George Gause, Chief Excavator; George Hudson (colored), Cook; George Dorsett (colored), Steward; and I later employed John Calhoun continuously, and other workmen, from time to time, to assist in the excavations. I make mention of the names of these men in order to express appreciation of the faithful and patient manner in which they performed their duties and assisted me throughout many trying days of labor in the water-soaked, foul-smelling muck and peat beds of Marco and neighboring keys. My acknowledgments are especially due to Gause, young Hudson, and Clark, who continually worked in the muck holes side by side with Mr. Bergmann and myself, and to whose painstaking care and attention it is due that many a fragile treasure was saved from destruction.

The voyage from Tarpon Springs to Marco, including a stop at Pine Island for mail and for taking in of fuel and water, occupied less than three days, and as there was a steady Gulf breeze and the tides were unusually high, we were able to make the difficult pass into Marco Inlet without hindrance. There, just to the northeast of the key, we anchored at a sufficient distance off shore to protect us measurably from the mosquitoes, and there our little craft rode at anchor during the two months occupied in the excavations and in my various expeditions to surrounding keys—for these were made in a light-draught, double-sailed sharpie, that had been fitted up and generously turned over for our use by Mr. Cheney.

Immediately on arriving at Key Marco, I made arrangements with Captain Collier whereby, in return for saving such muck as we should

turn over in our excavations, I would be permitted to retain all objects discovered, and if desirable, to exploit the little triangular "Court of the Pile Dwellers" from border to border. It lay, as I have said, close alongside the sea-wall at the southwestern edge of the key and just below a succession of shell benches, themselves formerly abandoned and filled-up courts of a similar character. The side opposite the sea-wall, that is on the east, was formed by an extended ridge—scarcely less high than the sea-wall itself, and likewise composed of well-compacted shells. Around the upper end, and down the outer side of this ridge, led—as indicated in plan, Plate XXXI—an inlet canal, bordered by similar ridges beyond, and joined by an outlet canal at the lower end—that continued through various low-banked enclosures in the mangrove swamps toward the south, quite down to the terminus of the sea-wall itself.

The entire court was thickly overgrown with mangrove trees, underneath which also thickly grew, to a uniform height of six or eight inches, bright green aquatic weeds and mangrove shoots. Since the interior of this artificial and filled-up bayou was still not above the level of the surrounding tide-swept mangrove swamps through which the canals led, it lay almost continually under water, and its excavation looked at first to be almost impossible, and at best a most formidable undertaking. It would be necessary to cut away and uproot the mangroves and in some way to remove the water that filled to overflowing the excavations which had formerly been made, and thus covered the entire court. To begin, I had a few of the trees cleared away from the outer and southwesterly corner, and opposite my old excavation in sections 34, 44, had a trench cut through the sea-wall to as great a depth as possible without letting water in from the bay outside. I then had a long trough of ship planks constructed and placed on stakes driven deep into the muck bed, so that one end rested over the excavation and the other, lower end, in the mouth of the sluice-way through the sea-wall. Then laying heavy planks over the boggy surface to furnish foothold for the men, I set them at work baling out the old excavation with buckets. It was at first like trying to bale out the sea itself, for water flowed in as fast as taken out; but after two or three hours of steady work, it began to lower, not only in the excavation, but over the entire court, and toward evening it became possible to even begin the extension of this original excavation in the direction of the cleared corner of the court. On the following morning, however, there was almost as much water in the excavation thus enlarged, and elsewhere, as on the previous day; but it was much sooner disposed of by baling and by the banking up of the place last excavated, and I soon found that by thus proceeding each morning for a couple of hours more or less, the water could be kept sufficiently low to enable us, working in sections, or bins as it were (roughly corresponding to those shown in the plan), to excavate the entire place. Yet, even thus, much of our search in the lower depths had to be made merely by feeling with the fingers.

I deem it unnecessary to give further details of our operations, save to say that three or four of us worked side by side in each section, digging inch by inch, and foot by foot, horizontally through the muck and rich lower strata, standing or crouching the while in puddles of mud and water; and as time went on we were pestered morning and evening by swarms and clouds of mosquitoes and sand-flies, and during the midhours of the day, tormented by the fierce tropic sun heat, pouring down, even thus early in the season into this little shut-up hollow among the breathless mangroves. After the first day's work, however, I was left no longer in doubt as to the unique outcome of our excavations, or as to the desirability of searching through the entire contents of the court, howsoever difficult the task might prove to be; for relics not only of the kind already described, but of new and even more interesting varieties, began at once to be found, and continued to be found increasingly as we went on day after day, throughout the entire five weeks of our work in this one little place. I may be permitted to add that never in all my life, despite the sufferings this labor involved, was I so fascinated with or interested in anything so much, as in the finds thus daily revealed. Partaking of my enthusiasm, the men, too, soon became so absorbed that they actually hated to see the sun go down and to thus be compelled to abandon their work even until the coming of another day.

As the northwesterly half of the court became cleared of its contents, and the bottom was thus more and more revealed, we found that it was generally concave, or perhaps I may say, tray-shaped; that is, comparatively shallow at the sides—not more than from eighteen inches to three feet deep—but throughout the middle and thence toward the mouths of the two canals, from four-and-a-half to five-and-a-half feet deep. Extending along the bottom, in toward this central deeper portion, from both the southwesterly and northwesterly margins at about equidistant intervals of twenty feet, were several straight, low benches or tongues, of compacted shell and tough clay-marl (shown in plan, Plate XXXI), from twenty-five to thirty feet long and from eight to twelve feet wide, level on top and built to a height gradually increasing from a few inches, where they joined the boundary banks, to nearly two feet at their rounded ends, so as to form low, originally submerged, slightly inclining piers, as it were. Along the opposite or eastern side was a similar, although continuous bench, uniformly some fifteen feet wide from its rounded upper end just below the mouth of the inlet canal, to a point about thirty feet below, whence it gradually narrowed to a width of less than eight feet at its lower end near the mouth of the outlet canal. Finally, across the extreme upper end or corner of the court, that is just to the left of and above the mouth of the same inlet canal, extended a like, although slightly wider and shorter bench. Thus the whole central portion of the court, as well as the spaces between the tongues or benches, had been left open and deep, as if for the free passage of canoes. Along the sides and around the ends of these in-reaching benches of shell and clay, occur-

red numerous piles of various lengths, all, however, comparatively short, blunt-pointed at their lower ends, and either squared or else rudely notched at their upper ends—some of them slantingly bored down the sides—and there occurred also many stakes and timbers; as though these benches had been built to serve actually as piers or the foundations for long, pile-supported quays or scaffolds; upon which, I concluded—from the character of many lesser remains that we continually found—had been constructed, side by side all around the court, comparatively long, narrow, and low, thatched and latticed houses. At any rate it was over and around these benches that the principal finds, inclusive of numerous household articles, were made.

The surface deposit throughout the entire court consisted of a stratum of spongy black or dark brown muck, permeated by both rotting and living rootlets. It was, as shown in section on Plate XXXI, thin at the margins, but eighteen or twenty inches thick throughout the middle. Below this was a somewhat thicker stratum of brownish gray peaty marl, soft, tremulous, exceedingly foul-smelling, and rich in the best preserved relics we discovered. This stratum directly overlaid and surrounded the benches I have described. Finally underneath it, between the benches and throughout the middle of the court, was a less well-defined layer of less peaty marl, intermixed with shells and other *débris*, and also with abundant ancient remains—which, indeed, we continued to encounter even in the underlying, comparatively firm shell and clay-marl bottom. This, however, although nearly a foot and a half thick, we could not venture to excavate, since the slightest opening made through it into the sandy reef below let in a steady stream of water from the sea.

The objects found by us in these deposits were in various conditions of preservation, from such as looked fresh and almost new, to such as could scarcely be traced through or distinguished from the briny peat mire in which they were embedded. They consisted of wood, cordage and like perishable materials associated with implements and ornaments of more enduring substances, such as shell, bone and horn—for only a few shaped of stone were encountered during the entire search.

Articles of wood far outnumbered all others. I was astounded to soon find that many of these had been painted with black, white, gray-blue, and brownish-red pigments; and that while the wood itself was so decayed and soft that in many cases it was difficult to distinguish the fibre of even large objects of it, either by sight or by touch, from the muck and peat in which they were unequally distributed, but now more or less integrated; yet when discoverable in time to be cautiously uncovered and washed off by the splashing or trickling of water over them from a sponge, their forms appeared not only almost perfect, but also deceptively well preserved, so that I at first thought we might, with sufficient care, recover nearly all of them uninjured. This was especially true of such as had been decorated with the pigments; for owing to the presence in these pigments of a gum-like and comparatively insolu-

ble sizing, the coatings of color were often relatively better preserved than the woody substance they covered, and enabled us the more readily to distinguish the outlines of these painted objects—when else some had been partially destroyed or altogether missed—and also enabled us to take them up on broad, flat shovels, and to more deliberately divest them of the muck and peat that so closely clung to them.

Some of the things thus recovered could be preserved by very slow drying, but it soon became evident that by far the greater number of them could not be kept intact. No matter how perfect they were at first, they warped, shrunk, split, and even checked across the grain, like old charcoal, or else were utterly disintegrated on being exposed to the light and air if only for a few hours. Thus, despite the fact that after removing the surface muck from the sections, we dug only with little hand-trowels and flexible-pronged garden claws—and, as I have said before, with our fingers—yet fully twenty-five per cent. of these ancient articles in wood and other vegetal material were destroyed in the search; and again, of those found and removed, not more than one-half retained their original forms unaltered for more than a few days.

Unique to archæology as these things were, it was distressing to feel that even by merely exposing and inspecting them, we were dooming so many of them to destruction, and to think that of such as we could temporarily recover only the half could be preserved as permanent examples of primitive art.

I sought by every means at our disposal to remedy these difficulties, but I soon found that the time thus required, and the cost of additional preservatives—if such could, indeed, be found, for ordinary glue, shellac, and silicate of soda, proved to be comparatively inefficient—would increase the cost of our operations considerably beyond my original estimates upon which appropriation had been made.

In this extremity I wrote to Major Powell, asking for suggestions as to methods for preserving our finds, and at the same time to Doctor Pepper, urging an additional appropriation. I was loath to do this, being well aware that the funds at the disposal of the Department he represented were already overtaxed by the many explorations progressing under his direction in other parts of the world. My relief of mind may be better imagined than described, when I say that as speedily as the mails could bring a letter from Doctor Pepper, he assured me that my operations looking toward the proper completion of our excavations and preservation of our collections would be supported to the extent required. It was not until afterward that I learned how a friend whom to know is to honor and revere, a friend to education and scientific research and human need wherever found, Mrs. Phebe A. Hearst, had, as a member of the Department of Archæology and Palæontology, come to our rescue. The gratification I feel in announcing the augmented success of our researches, thenceforward, is enhanced by the thought that I may here say how much this success was due to her instant recognition of the promise and significance of our finds.

Whilst I was still awaiting reply from my Director, Major J. W. Powell, and wondering as to the possible outcome of our undertakings—as to whether the extent of the field we had opened could, with such relatively imperfect results as I then looked for, be sufficiently represented to the scientific world to command due recognition of its significance ethnographically, I was happily honored by an unannounced visit from Major Powell himself. Instead of replying to my letter, he had immediately set out to visit us, in order to aid personally and on the spot in devising means for the preservation, if not of the collections, at least of a full and adequate record of our finds and discoveries. I had, therefore, the combined pleasure and advantage of exhibiting to him, alike the field of my observations and the results of our researches therein, and of gaining from him the approval of his trusted judgment as to not only these results, but also as to the methods whereby they had been achieved.

At this time, however, the season of rain and excessive heat had set in, rendering it certain that the days of the expedition in that section were numbered. Therefore after carefully inspecting our collections, Key Marco, and other typical shell settlements in that portion of the Ten Thousand Islands, Major Powell urgently counseled me to confine operations thenceforward to the completion of excavations in this one little court of the pile dwellers, and therewith to close for the season a work which he again assured me was of unusual archæologic significance and capable, he believed, of indefinite extension.

Thus aided and encouraged by my superiors, I persisted, notwithstanding the more or less destructive nature of our researches, if only in order that we might secure the fullest possible data. Fortunately we were in the end able not only to enlarge and complete our collections of photographic records, sketches, surveys and other field memoranda, but also to secure and bring away, in measurably good condition, more than a thousand of these precious examples of prehistoric art in perishable materials, not to mention many hundreds of examples in more durable substances such as shell, bone and horn.

I must further state that the various ancient artifacts we found in the muck, occurred at unequal depths and in all sorts of positions and relations. There were a few groups of utensils, for example, that obviously belonged together, like mortar cups and pestles, and sets of tools that were still associated; and there were also some few bundles or packs of ceremonial objects, apparently, which when found still remained almost intact; that is, their wrappings of reed matting, or neat swathings of flag or palmetto leaves still, looked fresh, actually green, in some cases; but on close examination they proved always to be pulpy with decay and impossible of removal. These packs and assemblages or bunches of related things, however, did not present the appearance of deliberate deposition. They looked as though they had fallen and sunken where we found them—some being upside down—as though they had been

hanging, or else lying, tucked away in the houses or on the scaffolds above, and had been washed out from or off of them into the water alongside and below, had become water-logged and had gradually been covered by mud and other *débris* and by the vegetal and other deposits we found them in.

By far the greater number of objects were, however, promiscuously scattered—although, as I have said, more abundant between and around the ends or along the edges of the low, submerged benches I have described, than elsewhere. Not a few of them—and this was especially the case with long and originally more or less fragile articles like spear-shafts and stays—appeared to have been broken in falling. Occasionally we found fragments separated by considerable distance which, when brought together, fitted perfectly. Not a few of the piles were thus broken, and many of the lesser timbers; while larger timbers, like the comparatively gigantic sill, which lay along the edge of the northern bench (in sections 29, 39, 40), were absolutely intact. They were excellent examples of primitive joinery; yet so soft and pulpy, as a rule, that on account of their great size and weight, we were unable to bring them away, or even, without destroying, to disturb them. Some of the broad, flat, notched staves—which I judged from considerations later offered had been used as symbolic ancestral tablets, probably attached to the gables of houses, or set up in altars—were lying on their edges; while flat boards sometimes stood on end, and other long, slender articles, stood slantingly upward, the lowermost ends or edges firmly stuck in the clay-marl of the bottom. This was the case, for example, with the beautifully shaped and pointed paddle which we found near the mouth of the upper or inlet canal. Its sharp point was slantingly and deeply embedded in the mud, while its long handle reached obliquely up nearly to the surface of the muck, and was there, as may be seen by examination of the specimen itself (or of Fig. 8, in Plate XXXII), burned off slantingly on a line that must have corresponded to the original level of the water, for at this point other charred specimens occurred, as though here fire had added its destructiveness to the storm that demolished the buildings or scaffolds from which all these things seemed to have fallen.

From the fact that many of the objects lay suspended, as it were, in the mud *above* the bottom, I judged that when these remains were thrown down into the little water court, the spaces between the house-benches and around the borders of the quays at least, must have been already choked up somewhat with *débris* or refuse and slime or mud; for out in the middle of the court where the deep open space occurred throughout the channel between the two canals, little was found in the way of art remains, except such as lay directly upon, or very near to, the bottom.

It may be seen that by a study of the distribution of these remains it was easy to determine what had been the original average depth of the water within the court, or at any rate, its depth at the time when these

things found their way into it, and to determine also many other features of the place, interesting as details and important too, as substantiating various inferences I have ventured to give above. But as a careful study of the collections themselves repeats to a great extent this story of our field observations, I will make haste to present a descriptive account of the various classes of these.

Ancient Artifacts from the Court of the Pile Dwellers.

Piles, Timbers, etc.—None of the piles found by us exceeded six and a half feet in length. Indeed, the greater number of them were less than three and a half feet long. These shorter piles were nearly always made of palmetto wood, were not round, but broad, or somewhat flattened, although the edges were rounded. They were tapered toward the bottom and bluntly pointed, rudely squared or hollowed out at the tops as though to support round, horizontal timbers; and they were bored or notched slantingly here and there through the edges, as though for the reception of rounded braces or cross-stays of poles or saplings, abundant pieces of which were found. Some of the piles were worn at the points or lower ends, as though they had rested upon, but had not been driven into, the solid shell and clay-marl benches. They had apparently, on the contrary, been quite rigidly fastened to the horizontal timbers or frameworks of the quays or scaffolds they held up—by means of the stay-sticks—like pegs or pointed feet, so that as long as the water remained low, they would support these house scaffolds above it, as well as if driven into the benches, but when the waters rose, the entire structures would also slightly rise, or at any rate not be violently wrenched from their supports, as would inevitably have been the case had these been firmly fixed below. The longer piles were, on the contrary, round. They were somewhat smaller, quite smoothly finished, and had been, if one might judge by their more pointed and yet roughened or frayed appearance at both ends, actually driven into the bottom. It therefore appeared to me that they had been made so as to be thus driven into the edges of the benches at either side of the peg-supported platforms, in order to keep these from swerving in case an unusual rise in the waters caused them to float. There were other pieces equally long, but broken off near their points. They were slightly grooved at the upper ends and tied around with thick, well-twisted ropes or cables made of cypress bark and palmetto fibre, as though they had served as mooring-posts, probably for the further securing of the ends of the partially movable platforms—else they had not been so violently wrenched as to break them at the points—for some of them were more than four inches in diameter, and were made of tough mangrove and buttonwood or iron-wood. The side-posts or stay-stakes were, on the contrary, of spruce or pine, and were, as I have said, finished to a nicety, as though to offer no resistance to the rise and fall of the big, partially floating quays between them. Around the great log or sill of cypress, mentioned as

lying along the edge of the northern bench (it was uniformly nine inches in diameter, fourteen feet eleven inches in length, carefully shaved to shape and finished evidently with shark-tooth blades and shell scrapers, and was moreover, like the piles, socketed and notched or bored along its sides) were many of these piles, both short and long; and overlying the sill, as well as on either side of it, I found abundant broken timbers, poles, and traces of wattled cane matting as well as quantities of interlaced or latticed saplings—laths evidently, for they seemed to have been plastered with a clay and ash cement—and quantities also of yellow marsh-grass thatch, some of it alluringly fresh, other portions burnt to black masses of cinder. Here and elsewhere along the edges of the benches occurred fire-hardened cement or mud hearth-plastering, mingled with ashes and charcoal—which indeed occurred more or less abundantly everywhere, together with refuse, consisting not only of broken and sometimes scorched animal bones and shells, but also of the charred remains of vegetable and fruit foods. Among these remains and the more artificial objects that were associated with them we continually encountered incipient or unfinished pieces—blocked-out trays or toy canoes, untrimmed adze and axe handles, uncompleted tablets, etc., and all this evidenced to me that the place was indeed a site of former daily occupation.

Furniture, etc.—Here and there were found curious wooden seats—more or less like ancient Antillean stools, as may be seen in Fig. 7, Pl. XXXIV—flat slabs of wood from a foot to more than two feet in length, slightly hollowed on top from end to end as well as from side to side, with rounded bottoms and substantial, prong-like pairs of feet near either end, from two to three inches long. Some of these stools had the feet level; others, so spread and beveled that they would exactly fit the hollow bottoms of canoes. Others still were smaller than those I have mentioned, so diminutive, in fact, that they could have served no purpose else, it seemed to me, than that of head-rests or pillow-supports. We found, indeed, although we were unable to preserve any of them, examples of what might have been the pillows used in connection with these rests. They were taperingly cylindrical, made of fine rushes, and showed a continuous four-ply plat, so that, like cassava strainers, they were flexible and compressible, yet springy, and they had probably been filled with Florida moss or deer hair, which filling had, however, long since disappeared save for a mushy residuum. Portions of mats, some thick, as though for use as rugs, others enveloping various objects, and others still of shredded bark in strips so thin and flat and closely platted that they might well have served as sails, were frequently discovered. Yet except for masses of the peat or mud upon which the remains of this matting lay and which therefore when dry showed traces of its beautifully and variously formed plies, naught of them could be preserved. It was obvious, however, that the peoples who had inhabited the court understood well, not only platting, but weaving and basketry-making too.

Pottery and Utensils.—A few examples of pottery were discovered lying always on or near the bottom, and with one exception invariably broken. All of these vessels, notwithstanding the fact that some of them had their rims more or less decorated, showed evidence of having been used as cooking bowls or pots. Associated with them were household utensils—spoons made from bivalves, ladles made from the greater halves of hollowed-out well-grown conch shells; and cups, bowls, trays and mortars of wood. These latter were in greatest variety and abundance. They ranged in size from little hemispherical bowls or cups two and a half or three inches in diameter, to great cypress tubs more than two feet in depth, tapering, flat-bottomed, and correspondingly wide at the tops. The smaller mortar-cups were marvels of beauty and finish as a rule, and lying near them and sometimes even within them, were still found their appropriate pestles or crushers—as is shown in Fig. 5, Pl. XXXIV. The smaller mortars and pestles, like the one illustrated, seemed to have been personal property, as though they had belonged to individuals and had been used in the crushing of berries and tubers, and perhaps cunti-root; as well as in other ways, that is, in the service, rather than merely in the general preparation, of food.

The trays were also very numerous and exceedingly interesting; comparatively shallow, oval in outline and varying from a length of six and a half or seven inches and a width of four or five inches, to a length of not less than five feet and a width of quite two feet. The ends of these trays were narrowed and truncated to form handles, the upper faces of which were usually decorated with neatly cut-in disc-like or semilunar figures or depressions. Looking at the whole series of them secured by us—no fewer than thirty in all—I was impressed with their general resemblance to canoes, their almost obvious derivation from such, as though through a sort of technologic inheritance they had descended from the vessels which had brought not only the first food, and the first supplies of water, to these outlying keys, but also the first dwellers thereon as well.

Navigating Apparatus and Fishing Gear. — This inference was strengthened by the discovery here and there of actual toy canoes. That they had been designed as toys was evident from the fact that some were not only well finished, but considerably worn by use. There were six or seven of these, and while they generally conformed to a single type, that is the dugout, they differed very materially in detail. Three of them were comparatively flat-bottomed. One, about five inches in length by two in breadth of beam and an inch in depth, was shaped precisely like a neat punt or flat-bottomed row boat—Fig. 7, Pl. XXXII. Both ends were somewhat squared, but the stern was wider than the prow, and above the stern was a little protuberance, indicating that such had been used in guiding, and perhaps as well in sculling, little light draught vessels like this, obviously designed, my sailors thought, for the navigation of shallow streams, inlets, bayous, and the canals. An-

other of these flat-bottomed little toy boats was much sharper and higher at the stem and stern, had very low gunwales, and was generally narrower in proportion to its length, and enlarged would have been admirably adapted to swift tidal currents, or to the running of low breakers. Yet another looked like a clumsy craft for the bearing over shoals of heavy loads or burdens. It was comparatively wide, and its ends also quite broad. All except one of these, I observed, were decorated at one end or both, with the same sort of semilunar or disc-like devices, that were observable on the trays—as may be seen by an examination of Fig, 6, Pl. XXXII. Two others of the toy canoes (one of which is here figured as just referred to) were not more than three inches broad by nearly two feet in length, gracefully and slenderly formed, tapered cleanly toward the forward ends, which were high and very narrow, yet square at the sterns, which were also high. We found them almost in juxtaposition near the midmost of the western benches. Little sticks and slight shreds of twisted bark were lying across them and indicated to me that they had once been lashed together, and, as a more finished and broken spar-like shaft lay near by, I was inclined to believe that they represented the sea-going craft of the ancient people here; that the vessels in which these people had navigated the high seas had been made double—of canoes lashed together, catamaran fashion—and propelled not only with paddles, but also, perhaps, by means of sails, made probably from the thin two-ply kind of bark matting I have before described, of which there were abundant traces near the midchannel, associated with cordage and with a beautifully regular, much worn and polished spar. At any rate, the natives of these South Florida seas and of the West Indies are mentioned by early writers as having navigated fearlessly in their cypress canoes; as having sometimes crossed the Gulf itself, and as having used in these long cruises sails of some simple sort. Jonathan Dickinson, in his quaint volume entitled *God's Protecting Providence Man's Surest Help and Defence*, etc.—one of the first books published in this city, by the way—narrates how, just two hundred years ago, he and his companion voyagers were shipwrecked on the Florida Gulf shore. He clearly describes such a double canoe as we found the toy remains of, when he tells how a Cacique, into whose hands they fell, went to wrest back the plunder that had been taken from them by earlier captors. The Cacique—to quote the author freely—came home in great state He was nearly nude and triumphantly painted red, and sitting cross-legged on their ship's chest, that stood on a platform midway over *two canoes lashed together with poles*. He maintained a fierce expression of countenance and looked neither to the left nor to the right, but merely exclaimed "wow" when they greeted him from the shore; and, after landing, proceeded—the author adds rather ruefully—to appropriate the contents of the chest to himself.

Two tackle-blocks, real prehistoric pulleys, that we found, may have pertained to such canoes as these. Each was three inches long, oval,

one side rounded, the other cut in at the edges, or rabbetted so to say. The tenon-like portion was gouged out midway, transversely pierced, and furnished with a smooth peg or pivot over which the cordage turned. I have already mentioned the finding of a paddle near the mouth of the inlet canal—which is shown in Fig. 8, Pl. XXXII. It was neatly shaped, the handle round and lengthy, although burned off at the end, and the blade also long, leaf-shaped, and tapered to a sharp point, convex or beveled on one side, flat or slightly spooned or concave on the other. The splintered gunwales and a portion of the prow of a long, light cypress-wood canoe, and various fragments of a large but clumsier boat of some soft spongy kind of wood—gumbo-limbo, probably—were found down toward the middle of the court. Not far from the remains of these I came across an ingenious anchor. It consisted of a bunch of large triton-shells roughly pierced and lashed together with tightly twisted cords of bark and fibre so that the long, spike-like ends stood out radiatingly, like the points of a star. They had all been packed full of sand and cement, so as to render them, thus bunched, sufficiently heavy to hold a good-sized boat. Near the lower edge of the eastern bench lay another anchor. It was made of flat, heart-shaped stones, similarly perforated and so tied and cemented together with fibre and a kind of red vegetable gum and sand, that the points stood out radiatingly in precisely the same manner. Yet another anchor was formed from a single boulder of coraline limestone a foot in diameter. Partly by nature, more by art, it was shaped to resemble the head of a porpoise perforated for attachment at the eye-sockets. Balers made from large conch shells crushed in at one side, or of wood, shovel shaped, or else scoop shaped, with handles turned in, were abundant; as were also nets of tough fibre, both coarse and fine, knitted quite as is the common netting of our own fisherman to-day, in form of fine-meshed, square dip-nets, and of coarse-meshed, comparatively large and long gill-nets To the lower edges of these, sinkers made from thick, roughly perforated umboidal bivalves, tied together in bunches, or else from chipped and notched fragments of heavy clam shells, were attached, while to the upper edges, floats made from gourds, held in place by fine net-lashings, or else from long sticks or square-ended blocks, were fastened. Around the avenues of the court I was interested to find netting of coarser cordage weighted with unusually large-sized or else heavily bunched sinkers of shell, and supplied at the upper edges with long, delicately tapered gumbo-limbo float-pegs, those of each set equal in size, each peg thereof partially split at the larger end, so as to clamp double half-turns or ingeniously knotted hitches of the neatly twisted edges-cords with which all were made fast to the nets. Now these float pegs, of which many sets were secured, varying from three and a half to eight inches in length of pegs, were so placed on the nets, that in consequence of their tapering forms they would turn against the current of the tide whichever way it flowed, and would con-

tinuously bob up and down on the ripples, however slight these were, in such manner as to frighten the fish that had been driven, or had passed over them at high tide, when, as the tide lowered, they naturally tried to follow it. In connection with these nets we found riven stays, usually of cypress or pine, such as might have been used in holding them upright. Hence I inferred that they had been stretched across the channels not only of the actual water courts of residence, like this, but, probably also, of the surrounding fish-pounds; and if so, that the supply of fresh fish must always have been abundant with the ancient inhabitants, both near at hand in these enclosures, as well as even among the quays of the actual residence courts.

We found four or five fish-hooks. The shanks or stems of these were about three inches long, shaped much like those of our own, but made from the conveniently curved main branches of the forked twigs of some tough springy kind of wood. These were cut off at the forks in such manner as to leave a portion of the stems to serve as butts, which were girdled and notched in, so that the sharp, barbed points of deer bone, which were about half as long as the shanks and leaned in toward them, could be firmly attached with sinew and black rubber-gum cement. The stems were neatly tapered toward the upper ends, which terminated in slight knobs, and to these, lines—so fine that only traces of them could be recovered—were tied by half-hitches, like the turns of a bow string. Little plug-shaped floats of gumbo-limbo wood, and sinkers made from the short thick columellæ of turbinella shells—not shaped and polished like the highly finished plummet-shaped pendants we secured in great numbers, but with the whorls merely battered off—seemed to have been used with these hooks and lines. That they were designed for deep-sea fishing was indicated by the occurrence of flat reels or spools shaped precisely like fine-toothed combs divested of their inner teeth. There were also shuttles or skein-holders of hard wood, six or seven inches long, with wide semicircular crotches at the ends. But these may have served in connection with a double kind of barb, made from two notched or hooked crochet-like points or prongs of deer bone, that we found attached with fibre cords to a concave round-ended plate, an inch wide and three inches long, made from the pearly nacre of a pinna shell. Since several of these shining, ovoid plates were procured, I regarded them as possibly "baiting-spoons," and this one with the barbed contrivance, as some kind of trolling gear, though it may, as the sailors thought, have been a "pair of grains," or may, like the hook proper, have been used for deep-sea fishing. Aside from these few articles, no other fishing tackle for use in the open waters was found; barbed harpoons being conspicuously absent. This led to the supposition that the ancient inhabitants had depended chiefly upon the pounds and water courts, whence with their nets they could at any time have readily drawn greater numbers of the fish for their supply.

Tools and Implements.—The working parts of the various instruments

of handicraft that we found were not of stone, but almost exclusively of hard organic substances—shell, bone, horn, and teeth—principally those of sharks—with their various kinds of wooden appurtenances or haftings, sometimes intact, sometimes merely indicated by the presence of fragments or traces—distinct enough, but too often wholly unrecoverable. In most cases these diverse parts were still in their original relation to one another, although, as a rule, the lashings by which they had been bound together—having consisted, as could plainly be seen by impressions left even in the surrounding mud, of rawhide thongs or of twisted sinew or fishgut—had wholly dissolved, or else remained merely as a dubious sort of gelatinous mass or slime. Such bindings had, however, in many instances been reinforced with cements of one kind or another—a sticky red substance, the stain only of which remained—or else rubber-gum, asphaltum, or a combination of rosin and beeswax and rubber, which still endured and retained perfect impressions of the fastening cords, whether coarse thongs or finely twisted threads.

We exercised great caution in keeping related parts together, and succeeded thus in recovering quite a number of examples of each of the many types most characteristic of the technical arts of the keys.

Large clam shells, deeply worn at the backs, as well as showing much use at the edges, seemed to have served both as scrapers and as digging implements or hoes; for some of them had been hafted by clamping curved sticks over the hinge and over the point at the apex or umbo—where it showed wear—precisely in such manner as LeMoine seems to have attempted to show in his representation—published in De Bry and other early works—of Indians planting corn.

Picks, hammers, adzes and gouges made from almost entire conch shells were found, handles and all, in relatively perfect condition and in considerable numbers. As may be seen by reference to the accompanying illustration, Fig. 1, Pl. XXXII, the conch-shell heads of these tools were most ingeniously hafted. The whorl was usually battered away on the side toward the mouth, so as to expose the columella. The lip was roundly notched or pierced, and the back whorl also perforated oppositely. Thus the stick or handle could be driven into these perforations, past the columella in such manner that it was sprung or clamped firmly into place. Nevertheless it was usually further secured with rawhide thongs—now mere jelly—passed through one or two additional perforations in the head, and around both the stick and the columella. The spike-like ends of the columellæ were so shaped as to form either long, sharp-pointed picks, flat, small-faced hammers or battering tools, adzes with very narrow bits, or gouges. The edges of the gouges were wider than those of the other tools, more of the wings of the shells having been left on the ends of the columellæ and these half-hollow points having been simply ground off obliquely. I made a tool of this description, which worked admirably on the hardest wood I could get; and retained

its edge amazingly well. Several very ingenious hacking tools or broad-axes had been made merely from the lips and portions of the outer or body-whorls of these conchs. They were simply notched at the ends so as to receive correspondingly grooved or notched sticks which were bound to their inner sides with thongs passed around the ends and over the backs. The wide, curved, natural edge of the lips, had then been neatly sharpened. Among the blocked-out pieces of wood so frequently found were examples of the work done not only with these hollow hacking tools, but also with the chisel- and gouge-pointed implements I have described, as was clearly shown by the results of my experiments. In addition to these cutting tools, celts, or rather celt-shaped, but curved adze-blades, two of them in connection with their handles—which were made from forked branches, one limb cut short and shouldered to receive the blade, the other left long, to serve as the handle—were also recovered. True celts were found too, made from the heavy columellæ of triton shells. One of them was accompanied by a pierced handle, the most elaborately decorated object of its kind thus far found in our country. It was superbly carved from end to end with curved volute-like decorations, concentric circles, ovals, and overpliced as well as parallel lines, regularly divided by encircling bands, as though derived from ornate lashings; while the head or extreme end was notched around for the attachment of plumes or tassels, and the opposite or handle-end furnished with an eyelet to facilitate suspension. Numbers of carving adzes, as was plainly indicated by marks of their work on both finished and unfinished objects, were also secured, quite in their entirety. Each consisted of a curved or crozier-shaped handle of hardwood about a foot in length, sharply crooked toward the head, which consisted of a perfectly fitted, carved, polished and socketed section of deer horn. The socket at the point of this deer-horn head was deep, transverse, and so shaped as to receive and retain measurably well, little blades made either from bits of shell, the sharp ventral valves of oysters—of which kind numerous worn-out examples were gathered—or sometimes, from very large shark or alligator teeth. These peculiar little hand-adzes—that resembled some of those one may see pictured in the figures of mask-carvers in Central American and Mexican codices—seem to have been, judged from the work performed with them, among the most perfect implements possessed by the inhabitants. That they were favorite tools also, was shown by the fact that many of them were elaborately carved. All had eyes, mostly protuberant, just above the sockets, and one, for example, was slightly crooked from side to side, and shaped to represent a fanged serpent; another had carved near its head, a surprisingly realistic horned-deer's head, and yet another was surmounted by the figure of a gopher or rodent gnawing at a stick—see Fig. 2, Pl. XXXII; and in these forms I did not fail to recognize the association that was attempted, by this sort of decoration between the carvings, and the functions of these biting or gnawing implements, so to call them.

Of course scrapers and shavers of various kinds abounded. Some, of large, finely-ribbed, serrated bivalves—varieties of pectunculus—were perforated at the apices, in order that a loop might be attached to them to facilitate handling. Others were made from the valves of tide-water unios, or sun-clams, so called, and showed no other art than that of having been keenly sharpened at the edges, and of the wear which had resulted from use. The most elaborate objects of this kind were, however, certain flat-hinged bivalves or arca shells, about three and a half or four inches long. The umboidal apices of these had been broken away and strips of bark, and in at least one case, broad straps of a kind of leather, had been so passed back and forth through the apertures, and platted along the hinges or straight backs, as to afford excellent grasp. All of them were crenulate at the edges and some of them were double, that is, made of two shells tightly tied together, one inside of the other, in such manner that a double edge was thereby secured. Several draw-knives made from split leg-bones of the deer sharpened to beveled edges from the inside; some ingenious shaving-knives, made from the outer marginal whorls of the true conchs—the thick indented or toothed lips of which formed their backs or handles, the thin but strong whorl-walls being sharpened to keen straight edges—completed the list of scraping and planing tools.

Cutting and carving knives of shark's teeth, varying in size from tiny straight points to curved blades nearly an inch in length and in width of base, were found by hundreds. Some were associated with their handles. These were of two classes. The greater number of them consisted of shafts from five to seven inches in length by not more than half or three-quarters of an inch in diameter at their thickest portions. Some were slightly curved, others straight, some pointed, others squared at the smaller ends. All were furnished with nocks at the lower ends—which were also a little tapered—for the reception of the hollow bases of the tooth-blades that had been lashed to them and cemented with black gum. Not a few of these doubly-tapered little handles were marvels of finish, highly polished, and some of them were carved or incised with involuted circlets or kwa-like decorations, or else with straight or spiral-rayed rosettes and concentric circles, at the upper ends, as though these had been used as stamps in the finishing of certain kinds of work. The other class of handles was much more various, and was designed for receiving one or more of the shark-tooth blades, not at the extremities, but at the sides of the ends, some transversely, others laterally. They were nearly all carved; a few of them most elaborately; and they ranged in length from the width of the palm of the hand to five or six inches, being adapted for use not only as carvers, but also, probably—such as had single crossblades—as finishing adzes.

Everywhere on the least finished surfaces of completed carvings, and on incipient works, not only in wood, but also in bone and horn, could be seen distinctive marks left by the finely serrated edges of these more

than half-natural carving tools. As soon as we had discovered a few of them I secured fresh teeth and experimentally made knives and cutters of the various kinds I have described. I found these diminutive shark-tooth blades—the one edge of each outwardly, the other inwardly, curved—by far the most effective primitive carving tools I had ever learned of, and therein perceived one of the principal causes of the pre-ëminence of the ancient key dwellers in the wood carver's art, so constantly evidenced in our collections. There were girdling tools or saws—made from the sharp, flat-toothed lower jaws of king-fishes—into the hollow ends of which curved jaw-bones, the crudest of little handles had been thrust and tied through neat lateral perforations ; but these also had formed admirable tools, and I found not a few examples of work done with them, in the shape of round billets that had been severed by them and spirally haggled in such a way as to plainly illustrate the origin of one of the most frequent decorations we found on carved wood works, the spiral rosette just referred to. There were minute little bodkin-shaped chisels of bone and shell, complete in themselves ; and there were, of course, numerous awls and the like, made from bone, horn and fish spines. Rasps of very small, much worn and evidently most highly prized fragments of coral sandstone, as well as a few strips of carefully rolled-up shark skin, told the story of how the harder tools had been edged, and the polished wood-, and bone-work finished, here.

Weapons.—It was significant that no bows were discovered in any portion of the court, but of atlatls or throwing sticks, both fragmentary and entire, four or five examples were found. Two of the most perfect of these were also the most characteristic, since one was double-holed, the other single-holed. The first—which is shown in Fig. 4, Pl. XXXII—was some eighteen inches in length, delicate, slender, slightly curved and originally, quite springy. It was fitted with a short spur at the smaller end and was unequally spread or flanged at the larger or grasping end. The shaft-groove terminated in an ornamental device, whence a slighter crease led quite to the end of the handle, and the whole implement was delicately carved and engrăved with edge-lines and when first taken from the muck exhibited a high polish and beautiful rosewood color. The other—shown in Fig. 3, Pl. XXXII—was somewhat longer, slightly thicker, wider shafted, more curved, and, as I have said before, furnished with only a single finger-hole. At the smaller end was a diminutive but very perfect carving of a rabbit, in the act of thumping, so placed that his erect tail formed the propelling-spur. This instrument also was fitted with a short shaft-groove and was carved and decorated with edge and side lines, and the handle-end was beautifully curved down and rounded so as to form a volute or rolled knob, giving it a striking resemblance to the ornate forms of the atlatl of Central America ; a resemblance that also applied somewhat to the double-holed specimen, and to various of the fragmentary spear-throwers. Arrows about four feet in length, perfectly uniform, pointed with hard

wood, the shafts made either of a softer and lighter kind of wood or of cane, were found. The nocks of these were relatively large. This suggested that certain curved and shapely clubs, or rather wooden sabres—for they were armed along one edge with keen shark-teeth—might have been used not only for striking, but also for flinging such nocked spears or throwing-arrows. Each of these singular and superbly finished weapons was about three feet long. The handle or grip was straight; thence the blade or shaft was gently curved downward and upward again to the end, which was obliquely truncated below, but terminated above in a creased or slightly bifurcated, spirally curved knob or volute like the end of a violin, and still more like the lower articulation of a human femur,—as may be seen by reference to Fig. 5, Pl. XXXII,—which the whole weapon resembled in general outline so strikingly that I was inclined to regard the type it represented as remotely derived from clubs originally made in imitation of thigh-bones. The handle was broader at the back than below, but neatly rounded, and the extreme end delicately flared to insure grasp. At both shank and butt of this grip, oblong holes had been bored obliquely through one side of the back for the attachment of a braided or twisted hand-loop or guard-cord, to still further secure hold. The back of the shaft, too, was wide, and sharp along the lateral edges, from both of which it was hollowed obliquely to the middle, the shallow V-shaped trough or groove thus formed reaching from the hilt to the turned-up end, where it terminated in a little semi-circular, sharp-edged cusp or spur in the central furrow at the base of the knob. The converging sides of the shaft were likewise evenly and sharply creased or fluted from the shank of the grip to the gracefully turned volutes at the sides of the knob. The blade proper, or lower edge, was comparatively thin, like a continuous slightly grooved tongue or an old-fashioned skate blade—save that it was obliquely square, not rounded, at the end. It was transversely pierced at regular intervals by semicircular perforations—twelve in all—beneath each of which the groove was deepened at two points to accommodate the blunt bifurcate roots of the large hooked teeth of the tiger- or "Man-Eater"- shark, with which the sabre was set; so that, like the teeth of a saw, they would all turn one way, namely, toward the handle, as can be seen by reference to the enlarged sketch of one at the end of the figure. Finely twisted cords of sinew had been threaded regularly back and forth through these perforations and alternately over the wings of the shark teeth, so as to neatly bind each in its socket; and these lashings were reinforced with abundant black rubber-gum—to which their preservation was due.

Now the little cusp or sharp-edged spur at the end of the back-groove was so deeply placed in the crease of the knob that it could have served no practical purpose in a striking weapon. Yet, it was so shaped as to exactly fit the nock of a spear, and since by means of the guard cord, the handle could be grasped not only for striking, but, by shifting or

reversing the hold, for hurling as well, I inferred that possibly the instrument had been used in part as an atlatl, in part as a kind of single-edged maquahuitl or blade-set sabre. It was, at any rate, a most formidable weapon and a superb example of primitive workmanship and ingenuity. There were other weapons somewhat like these. But they were only eight or nine inches in length, and were neither knobbed nor creased. They were, however, perforated at the backs for hand cords, and socketed below for six, instead of twelve teeth—set somewhat more closely together—and must have formed vicious slashers or rippers. Then there were certain split bear- and wolf-jaws—neatly cut off so as to leave the canines and two cuspids standing—which, from traces of cement on their bases and sides, appeared to have been similarly attached to curved clubs.

War clubs proper, that is, of wood only, were found in considerable variety. The most common form was that of the short, knobbed bludgeon. Another was nearly three feet long, the handle rounded, tapered, and furnished at the end with an eyelet for the wrist cord. The blade was flattish, widening to about three inches at the head, and it was laterally beveled from both sides to form blunt edges and was notched or roundly serrated, precisely as are some forms of Fijian and Caroline Island clubs. The type was obviously derived from some preëxisting kind of blade-set weapon. This was also true, in another way, of the most remarkable form of club we discovered. It was not quite two feet in length, and made of some dark-colored fine-grained kind of hard, heavy wood, exquisitely fashioned and finished. The handle was also round and tapering, the head flattened, symmetrically flaring and sharp-edged, the end square or but slightly curved, and terminating in a grooved knob or boss, to which tassel-cords had been attached. Just below the flaring head was a double blade, that is, a semilunar, sharp-edged projection on either side, giving the weapon the appearance of a double-edged battle-axe set in a broad-ended club, as indicated in outline *a* of Fig. 3, Pl. XXXV. This specimen was of especial interest, as it was the only weapon of its kind found, up to that time, in the United States; but was absolutely identical in outline with the so-called batons represented in the hands of warrior-figures delineated on the shell gorgets and copper plates found in the southern and central Mississippi mounds—as may be seen in the figure just referred to. It not only recalled these, but also typical double-bladed battle-axes or clubs of South and Central American peoples, from which type I regarded its form, although wholly of wood, as a derivative.

I must not fail to mention dirks or stilettos, made from the foreleg bones of deer, the grip ends flat, the blades conforming in curvature to the original lines of the bones from which they were made. One of them was exquisitely and conventionally carved at the hilt-end to represent the head of a buzzard or vulture, the which was no doubt held to be one of the gods of death by these primitive key-dwellers. There

were also striking- and thrusting-weapons of slender make and of wood, save that they were sometimes tipped with deer horn or beautifully fashioned spurs of bone, but they were so fragmentary that I have thus far been unable to determine their exact natures.

Personal Ornaments and Paraphernalia.—Numerous objects of personal investure and adornment were collected. Aside from shell beads, pendants and gorgets, of kinds found usually in other southern relic sites, there were buttons, cord-knobs of large oliva-shells, and many little conical wooden plugs that had obviously formed the cores of tassels ; sliding-beads, of elaborately carved deer horn—for double cords—and one superb little brooch, scarcely more than an inch in width, made of hard wood, in representation of an angle-fish, the round spots on its back inlaid with minute discs of tortoise shell, the bands of the diminutive tail delicately and realistically incised, and the mouth, and a longitudinal eyelet as delicately incut into the lower side. There were very large labrets of wood for the lower lips, the shanks and insertions of which were small, and placed near one edge, so that the outer disc which had been coated with varnish or brilliant thin laminæ of tortoise shell, would hang low over the chin. There were lip-pins too ; and ear buttons, plates, spikes and plugs. The ear buttons were chiefly of wood, and were of special interest—the most elaborate articles of jewelry we found. They were shaped like huge cuff buttons—some, two inches in diameter, resembling the so-called spool-shaped copper bosses or ear ornaments of the mound builders (see *d* and Fig. 3, Pl. XXXV). But a few of these were made in parts, so that the rear disc could be, by a partial turn, slipped off from the shank, to facilitate insertion into the slits of the ear lobe. The front discs were rimmed with white shell rings, within which were narrower circlets of tortoise shell, and within these, in turn, little round, very dark and slightly protuberant wooden bosses or plugs, covered with gum or varnish and highly polished, so that the whole front of the button exactly resembled a huge round, gleaming eyeball. Indeed, this resemblance was so striking that both Mr. Sawyer and I independently recognized the likeness of these curious decorations to the glaring eyes of the tarpons, sharks, and other sea monsters of the surrounding waters ; and as the buttons were associated with more or less warlike paraphernalia, I hazarded the opinion that they were actually designed to represent the eyes of such monsters—to be worn as the fierce, destructive, searching and terrorizing eyes, the "Seeing Ears," so to say, of the warriors. This was indicated by the eye-like forms of many of the other ear buttons we found—some having been overlaid in front with highly polished concavo-convex white shell discs, perforated at the centres as if to represent eye pupils,—as in *f*, of the figure last referred to.

There were still other ear buttons, however, elaborately decorated with involuted figures, or circles divided equally by sinusoid lines, designs that were greatly favored by the ancient artists of these keys. The origin of these figures, both painted, as on the buttons—in contrasting

blue and white—and incised, as on discs, stamps, or the ends of handles, became perfectly evident to me as derived from the "navel marks," or central involutes on the worked ends of univalvular shells; but probably here, as in the Orient, they had already acquired the significance of the human navel, and were thus mystic symbols of "the middle," to be worn by priestly Commanders of the warriors. That the ear buttons proper were badges, was indicated by the finding of larger numbers of common ear plugs; round, and slightly rounded also at either end, but grooved or rather hollowed around the middles. Although beautifully fashioned, they had been finished with shark-tooth surface-hatching, in order to facilitate coating them with brilliant varnishes or pigments. The largest of them may have been used as stretchers for ordinary wear; but the smaller and shorter of them were probably for ordinary use, or use by women, and had taken the place of like, but more primitive ornaments made from the vertebræ of sharks. Indeed a few of these earlier forms made of vertebræ, were actually found.

I could not quite determine what had been the use of certain highly ornate flat wooden discs. They were too thin to have been serviceable as ear plugs, or as labrets. But from the fact that they were so exquisitely incised with rosettes, or elaborately involuted, obliquely hatched designs, and other figures—the two faces different in each case—and that they corresponded in size to the ear buttons and plugs, I came to regard them as stamps used in impressing the gum-like pigments with which so many of these ornaments had been quite thickly coated, as also, perhaps, in the ornamentation or stamping of other articles and materials now decomposed. Very long and beautifully finished, curved plates of shell had been used probably as ear ornaments or spikes, also; since they exactly resembled those depicted as worn transversely thrust through the ears, in some of Le Moyne's drawings, of which representations I had never previously understood the nature; and many of the plummet-shaped pendants I have before referred to, must have been used after the manner remarked on in some of the old writers, as *ear weights* or stretchers, and some, being very long, not only thuswise, but also as ear spikes for wear after the manner of using the plates just described. While certain crude examples of these curious pendants had been used apparently as wattling bobbets, still others, better shaped, had as certainly served as dress or girdle pendants. On one of them, made from fine gray coral stone—in form like a minute, narrow-necked, pointed flask—the attachments were so completely preserved that the delicate cords, intricately and decoratively interlaced to and fro from the groove cord surrounding the neatly turned rim, to the central knot over its small flat head, were still perfectly visible, the whole having been coated with shining black gum or varnish. I may add, however, that some of the cruder and heavier of these shell, coral, and coral-stone plummets, must have served purely practical ends. Not a few had almost unquestionably been used, as I have said, as wat-

tling weights and netting bobbetts, their hurried finish, their adaptability to such uses and their numbers and the uniformity of many of them, all indicated this. Others, no doubt, had served as fish-line weights. Still, several of the more elaborate of them were not only decorated, but were so beautifully shaped and so highly polished that they could have been employed only as combined stretchers and ornaments or as insignia of a highly valued kind.

The remains of fringes and of elaborate tassels, made from finely spun cords of the cotton-tree down—dyed, in one case green, in another yellow—betokened high skill in such decorative employment of cordage. The remains, too, of what I regarded as bark head-dresses quite similar to those of Northwest Coast Indians, were found. Associated with these, as well as independently, were numbers of hairpins, some made of ivory, some of bone, to which beautiful, long flexible strips of polished tortoise shell—that, alas, I could not preserve in their entirety—had been attached. One pin had been carved at the upper end with the representation of a rattlesnake's tail, precisely like those of Cheyenne warriors; another, with a long conical knob grooved or hollowed for the attachment of plume cords. Collections of giant sea-crab claws, still mottled with the red, brown, orange, yellow and black colors of life, looked as though they had been used as fringe-rattles and -ornaments combined, for the decoration of kilts. At all events their resemblance to the pendants shown as attached to the loincloth of a man, in one of the early paintings of Florida Indians preserved in the British Museum, was perfect. Here and there, bunches of long, delicate, semi-translucent fish-spines indicated use either as necklaces or wristlets; but generally such collection were strung out in a way that led me to regard them as pike-, or shaft-barbs.

Certain delicate plates of pinna-shell, and others of tortoise-shell, square—though in some cases longer than broad—were pierced to facilitate attachment, and appeared to have been used as dress ornaments. Still other similar plates of these various materials, as well as smaller, shaped pieces of differing forms, seemed to have been inlaid, for they were worn only on one side, the outer, and a few retained traces of black gum on the backs or unworn sides.

Considerable collections or sets of somewhat more uniform tortoise-bone and pinna-shell plates, from an inch and a half to nearly three inches square, were found closely bunched together, in two or three separate places. None of them were perforated. Moreover, nearly all were worn smooth on both faces, and especially around the edges, as though by much handling. Hence it appeared that they had not been used as dress ornaments, or for inlaying or overlaying. One characteristic was noteworthy. In each collection, or set, which consisted of from twenty or more to forty or more pieces, a small proportion were distinguished from the others by difference in length or in material or in surface treatment. In one lot of between forty and fifty tortoise-bone

plates, for example, there were four or five plates of pinna-shell, while on one of the tortoise-bone plates themselves were circularly incised the dolphin-like figures of two porpoises "wheeling" in the water—one above, the other below the medial suture of the bone, the line of which evidently represented the rippling surface of the water, for the figure above it was spiritedly depicted "blowing"—that is, with mouth open—the one below it, with mouth closed, as though holding the breath. Now from the fact that these differences were very marked in each set, and that many of the tortoise-bone plates of each, whether still covered with traces of the original epiderm or not, were so cut from the carapace at the intersections of the sutures, as to include portions of from one to six nearly equal-sized segments, I judged that possibly these *sets* of the plates, at least, had been used in sacred games, or perhaps in processes of divination—for abundant evidence that the tortoise and turtle were here—as in the Orient, and elsewhere in America,—held sacred, occurred with our finds in other parts of the court.

It will be observed that suggestions as to quite diverse uses of both the plummet-shaped objects and these plates, have been offered. In some cases these diverse uses of single types were perfectly manifest, but in others merely inferential. Let me repeat that there was frequently (and this was especially true of personal paraphernalia) evidence as to quite varied use of identical forms. It is always difficult to determine as specific, the purpose of a primitive art-form, for the high degree of differentiation characteristic of modern art was not developed generally in primitive art. It is particularly difficult to distinguish between the purely ceremonial and the more or less ornamental in such personal paraphernalia as I have been describing. To a certain extent all personal adornments, so called, of early peoples, are ceremonial or sacred, since the most rare and beautiful objects are like to be regarded by them as also the most effective charms or medicine potencies, if only because of their rarity, their substances and their colors.

As typical of primitive ornament proper I may mention the beads and pendants and certain of the gorgets of shell which we discovered. While it is true that even such objects were probably, as with other primitive peoples, supposed to be sacred,—for instance, on account of their substance and white color, because related by appearance to the shell-like white foam of the blue sea, and to the light or white splendor of day in the blue sky—the fact that they were found indiscriminately associated with other remains indicated equally indiscriminate use—use, that is, as ornaments more or less in our acceptation of the term. The commonness of the material of which they were made caused them to be prized less on account of their nature and beauty, than on account of the labor they represented. This is also indicated by the fact that their forms (wrought in species of shell here more common than elsewhere on the gulf coast), are nevertheless very widely distributed throughout other portions of Florida and all the Southern and Central Mississippi States;

a fact which argues that they, like the wampum of other regions, were used as the media of trade, or the basis of definite exchange valuation, as well as, in case of the more elaborate of them, in the solemnization of treaties. But by far the greater number of the articles of personal adornment described in preceding paragraphs, were more than this. They were found not indiscriminately, but definitely associated with other ceremonial remains. They may therefore be regarded as having been especially sacred, used as amulets, and in many cases, as at the same time badges of office, birthright, or priestly rank. Certainly this may be judged true of such as had been given distinctive forms, for semblance or form is to the primitive-minded man, the most significant character of any thing. The ear buttons already described illustrate this, as well as certain of the gorgets. These were about three inches in diameter, discoidal, and each cut out from the labrum of a pyrula or conch, to represent a broad circle enclosing a cross. Above the end of the upper arm of this cross, four holes were drilled (instead of one), for suspension. The margin of the inner side was, moreover, scored with definite numbers of notches. Thus it was plain that to the primitive nature worshipers who made and used such gorgets the circle represented the horizon surrounding the world and its four quarters—typified by the cross as well as the four holes or points—the notches in its rim, the score of sacred days in the four seasons pertaining to the four quarters thus symbolized; and that this kind of ornament, if we may still call it such, was the combined cosmical and calendaric badge, probably of the priest who officiated in, and kept tally of, the ceremonials, and ceremonial days, of the successive seasons.

Miscellaneous Ceremonial Appliances; Sacred and Symbolical Objects; Carvings and Paintings.

Less difficulty attended the determination of other than the strictly personal appliances of ceremonology which we found; and again, many articles of both these classes, the meaning of which might have been problematical had we found them dissociated, were readily enough recognized when found together. This was particularly the case with a heterogeneous collection of things I discovered close under the sea wall, at the extreme western edge of the court. I regarded its contents as having constituted the outfit of a "Medicine man," or Shamanistic priest. It is true that it contained several articles of a purely practical nature. There were two or three conch-shell bailers; one or two picks or battering tools of conch-shell, of a kind already described; and a hammer of a sort not infrequently found elsewhere. It was made from a large triton-shell by removing the labrum or two first larger whorls, from the columella, and leaving this to serve as the handle, while the remaining four or five smaller or apical whorls were left to serve as the head. There were also several hollow shaving-blades or rounding-planes, made from the serrate-edged dental plates or

mandibles of the logger-head turtle, and some shell chisels and cutters of various other sorts.

For the rest, however, this curious assemblage of things both natural and artificial, were, judged by their unquestionable relationship to one another, certainly sacred, or fetishistic. No other purpose could be assigned to several natural but extremely irregular pearls; peculiarly shaped, minute pebbles and concretions; water-worn fragments of coral exhibiting singular markings, such as regular lines of star-like or radiate dots; more than twenty distinct species of small, univalvular shells, and half as many of small bivalves—all quite as fresh as though but recently gathered. These were mingled with oliva-shell buttons and pendants, and pairs of sun-shells (solenidæ), two of which had been externally coated with a bright yellow pigment, and others of which had once been painted, inside, with symbolic figures or devices in black, although the lines of these figures could now no longer be distinctly traced. There were a number of interesting remains of terrestrial animals. One was the skull of an opossum. It had been carefully cleaned, and cut off at the occiput, and to the base thus formed, the under jaw had been attached frontwardly at right angles, in such manner that the object could be set upright. The whole had been covered with thick, white pigment, and on this background lines in black, representative of the face marks or features of the living animal, as conventionally conceived, had been painted, doubtless to make it fetishistically "alive and potent" again. Another skull, that of the marten or weasel, occurred in this little museum of a primitive scientist; and since we know that both the opossum and the weasel were favorite "mystery animals" of Indian Shamans elsewhere, little doubt remains as to the character of the collection they belonged to. But there were other more artificial objects, yet of a kindred kind. There were kilt-rattles, made from peculiarly mottled claw shells of both the small sea-crab and the great king-crab; and a set of brilliant colored scallop shells, and another set of larger pecten shells, all in each set perforated, obviously for mounting together on a hoop, to serve as castanets, precisely as are similar shells among the Shamans of the far-away Northwest coast. There was still another kind of rattle—duplicated elsewhere—made from the entire shell or carapace of a "gopher," or land-tortoise, the dorsal portion of which was very regularly and neatly drilled, to aid the emission of sound. As though to show us that the original owner of this collection was not only a sacred song-man and soothsayer or prophet, but also a doctor, there were, in addition, a beautiful little sucking tube made from the wing-bone of a pelican or crane, and near at hand a sharp scarifying lancet of fish bone set in a little wooden handle, of precisely the kind described by old writers as used by the Southern Indians in blood letting and ceremonial skin-scratching.

In addition to these and other objects largely of natural, or of only partially artificial origin, there were a number of highly artificial things.

Most interesting of these and conclusively significant of the nature of the find, was what I regarded as a set of "Black-Drink" appliances. It consisted of a gourd, the long stem of which had been perforated at the end and sides; of a tall wooden cup or vase—brewing-churn and drinking-drum, in one; of a toasting tray of black earthenware punctured around the rim to facilitate handling when hot, and of a fragmentary, but nearly complete, sooty boiling-bowl or hemispherical fire-pot, also of black earthenware. Near by were two beautifully finished conch-shell ladles or drinking cups, both rather smaller and more highly finished than others found in different parts of the court. The larger one was still stained a deep reddish brown color inside, as though it had been long used for some dark fluid like coffee, and uncleansed, or too deeply stained for cleansing.

Now by reference to Laudonnier's relation of Ribault's and his own efforts to colonize Florida, some three hundred years ago, and especially by reference to Jonathan Dickenson's narrative of his reception by the self-same "Cassekey"—who, it will be remembered, later despoiled him and his party—one can see that these things quite undoubtedly pertained, as I have intimated, to the brewing and ceremonial serving of the sacred Cassine or 'Black-Drink" so famous among all Southern Indians; for they correspond in a general way quite remarkably to those described by this author, so much so, that I do not hesitate to quote his account at length. He says:

"The Indians were seated as aforesaid, the Cassekey at the upper end of them, and the range of cabins was filled with men, women and children, beholding us. At length we heard a woman or two cry, according to their manner, and that very sorrowfully . . . . which occasioned some of us to think that something extraordinary was to be done to us; we also heard a strange sort of a noise, which was not unlike the noise made by a man, but we could not understand what, nor where it was; for sometimes it sounded to be in one part of the house, sometimes in another, to which we had an ear. And indeed our ears and eyes could perceive or hear nothing but what was strange and dismal, and death seemed to surround us; but time discovered this noise to us—the occasion of it was thus: In one part of this house, where a fire was kept, was an Indian man, having a pot on the fire, wherein he was making a drink of a shrub (which we understood afterwards by the Spaniards, is called Casseena) boiling the said leaves, after they had parched them in a pot; then with a gourd, having a long neck, and at the top of it a small hole, which the top of one's finger could cover, and at the side of it a round hole of two inches diameter. They take the liquor out of the pot, and put it into a deep round bowl, which being almost filled, contains nigh three gallons; with this gourd they brew the liquor, and make it froth very much; it looks of a deep brown color. In the brewing of this liquor was this noise made, which we thought strange; for the pressing of the gourd gently down into the liquor, and the air which it contained, being forced out of the little hole at the top, occasioned a sound, and according to the time and motion given, would be various. This drink when made and cool to sup, was in a shell first carried to the Cassekey, who threw part of it on the ground, and the rest he drank up, and then would make a loud hem; and afterwards the cup passed to the rest of the Cassekey's associates,

as aforesaid; but no other man, woman or child must touch or taste of this sort of drink; of which they sat sipping, chattering, and smoking tobacco, or some other herb instead thereof, for the most part of the day."

A much fuller account of this solemn ceremonial, of the making and administering of the "Black-Drink," as well as of its meaning at almost every stage, is given in the admirable annals of William Bartram—a former and honored member of this Society—whose works are, indeed, the source of more definite information regarding the Southern Indians than those of any other one of our earlier authorities on the natives of northerly Florida and contiguous States.

Three other objects in the curious lot of sacerdotal things I have been describing were especially typical; for closely related, but varied forms of them were found at several other points throughout the area we excavated. One was a small, square, paddle-like tablet, about six inches long, three inches wide, and five-eighths of an inch thick. At one end, presumably the lower, was a sort of tenon; that is, the board was squarely cut in from either side to the middle, where a projection about an inch wide and a little more than an inch long was left, as though either for insertion into a mortice, or to facilitate attachment to something else, otherwise. A much larger tablet or board, an inch thick and six or seven inches wide, by nearly two feet in length, also tenoned in like manner at the lower end, lay on edge near by. Along the middle of one face of this tablet, two elongated figures were cleanly cut in or outlined, end to end, figures that seemed to represent shafts with round terminal knobs—indicated by circles—the sides of the shafts being slightly incurved, so that the figures as a whole greatly resembled the conventional delineations of thigh bones as seen in the art-works of other primitive peoples—in, for example, the codices, and on the monuments, of Central America. Another tablet of this sort, somewhat wider, longer, and more carefully finished by the shaving down of its surfaces with shark-tooth blades, showed likewise along the middle of one face similar devices, carved, however, in relief, as though to represent a pair of thigh bones laid lengthwise and end to end upon, or rather, set into the centre of one side of the board.

Near the first described of these curious objects which I regarded as probably mortuary, was another tablet, evidently of related character; but it was much more elaborate. The lower portion was tenoned and in general outline otherwise resembled the tablets I have described; but above this portion, midway from end to end, it was squarely notched in at either side, and above the stem thus formed, extended, in turn, a shovel-shaped head, or nose, so to call it, as may be better perceived by reference to Fig. 2, Pl. XXXIV, which represents the most perfect of these objects that we found. The specimen in question was between three and four feet long, although less than a foot in width. The lower portion was not more than an inch in thickness, and was uniformly flat, the upper portion—head or nose, as I have called

it—was convex on one side, flat on the other. When I found this object I encountered the somewhat rounded shovel-shaped end first. and thought that I had found a paddle. Following it up by feeling with my fingers along the edges, I became assured that this was so. when I struck the notched-in portions at the stem which connected it with the lower or flatter and squarer portion. Then when the shoulders of this in turn were touched, I supposed it to be a double sort of paddle. I discovered my mistake only when the entire object was revealed. These curious tablets, tenoned at the lower ends, notched in midway, and terminating in long shovel-shaped extensions beyond the necks thus formed, were represented by no fewer than ten or twelve examples besides the one described. They were found quite generally distributed throughout the court. But they varied in size from a foot in length by three inches in width, to nearly five feet in length, by more than a foot in width. The most elaborate of them all was the one already referred to, and shown in Pl. XXXIV, for it, like the first specimen found, had been decorated with paint (as at one time probably had been all of the others). Upon the head or shovel-shaped portion were two eye-like circles surrounding central dots. At the extreme end was a rectangular line enclosing lesser marginal lines, as though to represent conventionally a mouth enclosing nostrils or teeth or other details. The body or lower and flatter portion was painted from the shoulders downward toward the tail-like tenon with a double-lined triangular figure, and there were three broad transverse black bands leading out from this toward either edge. On the obverse or flat under surface of the tablet were painted equidistantly, in a line, four black circles enclosing white centres, exactly corresponding to other figures of the sort found on various objects in the collections, and from their connection, regarded by me as word-signs, or symbols of the four regions.

That these curious tablets were symbolical—even if designed for attachment to other more utilitarian things—was indicated by the fact that various similar objects, too small for use otherwise than as batons or amulets, were found. Several of these were of wood, but one of them was of fine-grained stone (Fig. 3, Pl. XXXIV), and all were exquisitely finished. Those of wood were not more than eight inches in length by three inches in width; and they were most elaborately decorated by incised circles or lenticular designs on the upper convex sides—still more clearly representing eyes—and by zigzag lines around the upper margins as clearly representing mouths, teeth, etc., and on the same side of the lower portions or bodies, by either triangular or concentric circular figures; while on the obverse or flat side of one of them was beautifully incised and painted the figure of a Wheeling Dolphin or Porpoise, one of the most perfect drawings in the collection. The little object in stone (disproportionately illustrated in Fig. 3, Pl. XXXIV) was only two inches in length by a little more than an inch in width. It was wrought from very fine dioritic stone, and as may be seen by the

illustration was so decorated with incised lines as to generally resemble the comparatively gigantic wooden object of the same general kind shown above it. The very slight tenon-like projection at the lower end of it was, however, grooved, as if for attachment by a cord. Plainly, therefore, it was designed for suspension, and no doubt constituted an amulet representative of the larger kind of object. The moderately small, highly finished wooden figures of this kind, seemed also to have been used more as portable paraphernalia—as batons or badges in dramatic or dance ceremonials perhaps—than for permanent setting up or attachment. That this may have been the case was indicated by the finding of a "head-tablet" of the kind. It was fifteen inches in length by about eight inches in width, although wider at the somewhat rounded top than at the bottom. On the flatter, or what I have called the under side of the lower portion or end, this tablet was hollowed to exactly fit the forehead, or back of the head, while on the more convex side, it was figured by means of painted lines, almost precisely as were the upper surfaces of the small wooden batons or minature carved tablets. My conclusion relative to its character as a "head-tablet" was based, not only upon the fact that it was thus hollowed as though to fit the head, but also upon the comparison of its general outlines and those represented on its painted surface, with the outlines and delineations on certain objects represented on the head-dresses of human figures etched on shell gorgets found in the ancient mounds of the Mississippi Valley.

I admit that the significance of not only the smaller, but also of the larger of these remarkable tablets must remain more or less enigmatical; yet, judged by their general resemblance to the gable-ornaments upon the sacred houses and the houses of the dead of various Polynesian peoples, and to corresponding sheet-copper objects of the northwest coast, as well as to their obvious connection with the tablets found by us, on which conventional representations of thigh bones occurred, I was led to believe that at least all of the larger of them were ancestral emblems; that the smaller and more highly finished of them were, therefore, for ceremonial use, perhaps, in dramatic dances of the ancestry, in which also such head-tablets as the one I have described were used; and that such amulets as the little one of stone here figured, were likewise similarly representative. It may be, however, that while there is no question as to the symbolic and ceremonial nature of all these things—as is indicated by the like conventional devices upon them all,—nevertheless, the larger of them may have been used in other ways; as. for example, on the prows of canoes, or at the ends of small mortuary structures—chests or the like—or they may have been set up to form portions of altars. But in any one of these uses they might well have served quite such a symbolic purpose as I have suggested; for they were obviously more or less animistic and totemic, and it is for this reason that I have provisionally named the larger of them "Ancestral Tablets," and look upon the smaller of them as having been used either as amu-

lets or to otherwise represent such tablets in the paraphernalia of sacred ancestral ceremonials. I may add that I believe it will yet be possible, by the experimental reproduction and use of these forms, to determine more definitely what the originals, the most mysterious of our finds, were designed for.

In addition to the head tablet I have spoken of, various thin, painted slats of wood were found in two or three places. They were so related to one another in each case, that it was evident they had also formed portions of ceremonial head-dresses, for they had been arranged fan-wise as shown by cordage, traces of which could still be seen at their bases. Besides these, other slats and parts of other kinds of head-dresses, bark tassels, wands—one in the form of a beautifully shaped spear, and others in the form of staffs—were found; many of them plainly indicating the practice of mimetically reproducing useful forms, and especially weapons, for ceremonial appliance.

Perhaps the most significant object of a sacred or ceremonial nature, however, was a thin board of yellowish wood, a little more than sixteen inches in length, by eight and a half inches in width, which I found standing slantingly upward near the central western shell-bench (Section 22). On slowly removing the peaty muck from its surface, I discovered that an elaborate figure of a crested bird was painted upon one side of it, in black, white, and blue pigments, as outlined in Fig. 1, Pl. XXXIV. Although conventionally treated, this figure was at once recognizable as representing either the jay or the king-fisher, or perhaps a mythologic bird-being designed to typify both. There were certain nice touches of an especially symbolic nature in portions of this pictorial figure (and the same may also be said of various other figures illustrated in the plates), the nicety of which is not sufficiently shown in the drawings, that were unfortunately made from very imperfect prints of our photographs. It will be observed, however, not only that considerable knowledge of perspective was possessed by the primitive artist who made this painting, but also that he attempted to show the deific character of the bird he here represented by placing upon the broad black paint-band beneath his talons (probably symbolic of a key), the characteristic animal of the keys, the raccoon; by placing the symbol or insignia of his dominion over the water—in form of a double-bladed paddle—upright under his dextral wing; and to show his dominion over the four quarters of the sea and island world thus typified, by placing the four circles or word-signs, as if issuing from his mouth,—for in the original, a fine line connects this series of circlets with his throat, and is further continued downward from his mouth toward the heart,—as is so often the case with similar representations of mythologic beings in the art of correspondingly developed primitive peoples.

On exhibiting this painting to that learned student of American linguistics, Dr. Albert S. Gatchet, of the Bureau of American Ethnology, and stating to him that I regarded it as that of the crested jay, or of the king-

fisher, he called my attention to the fact that among the Maskokian tribes of Georgia, and of contiguous southern regions, the name of a leader among the recognized warriors signified "He of the Rising Crest," and that this name was also that of the jay whose crest is seen to rise when he is wrathful or fighting. I am therefore convinced that this figure, so often found in the south and in other parts of Florida (and usually identified as that of the ivory-billed woodpecker), really represented the bird-god of war of these ancient people of the keys, his dominion over the water being signified, as I have suggested, by his double-bladed paddle ; his dominion over the four quarters of the world, by the four word-signs represented as falling from his open mouth—for these circular signs, as we have seen before, were not only drilled in the margin of gorgets symbolic of the four quarters, but were also inscribed upon some of the tablets I have called "Ancestral."

Other, smaller, thin painted boards were found, but it was evident that they were lids or other portions of boxes,—some of which, indeed, we found nearly complete. One of these lids was not more than seven inches in length, by four inches in width. Upon one side of it was drawn, in even, fine lines of black (as approximately shown in Fig. 6, Pl. XXXIV), the representation of a horned crocodile. Again, in this as in the painted tablet, may be seen a clear indication of a knowledge of perspective in drawing, on the part of the primitive artists who designed it. This is apparent in the treatment of the legs, of the serrated tail, and of the vanishing scales both at the back and under the belly of the figure. Such knowledge of *delinative art in the round*—remarkable with a people so primitive—was, I believe, derived by them from their still more remarkable facility in relief work, in wood carving ; and this, in turn, originated, I think, in their possession of those admirable carving-tools of shark teeth that I have previously described The little lid in question was found still in connection with the ends and with one side of a jewel-box, in which had been placed several precious things, among them, two sets of ear buttons and choice, carved wooden and shell discs. It was enfolded within decayed matting containing a bundle or pack, in which were also nine ceremonial adzes, a pair of painted shells, a knife with animistically carved handle, and other articles—all evidently sacred, or for use in the making of sacred objects. The little figure of the crocodile painted on this lid, was of interest in another way. Being horned, it at once called to mind the "horned alligators," described by Bartram and others, as painted upon the great public buildings of the Creeks or Maskokian Indians of the States just north of Florida. Upon another box-lid or tablet was painted in outline, a graceful and realistic figure of a doe, and along the middles of the ingeniously rabbetted sides and ends of these boxes—whether large or small—were invariably painted double lines, represented as tied with figure-of-eight knots, midway, or else fastened with clasps of oliva shell—as though to mythically join these parts of the boxes and secure their contents.

The painted shells I have referred to as contained in the pack just described, were those of a species of Solenidæ, or the radiatingly banded bivalves that are locally known in that portion of Florida as "sun-shells." Each pair of them was closed and neatly wrapped about with strips of palmetto leaves that were still green in color, but which of course immediately decomposed on exposure to the air. On opening this pair of them, I found that in one of the lids or valves, the left one, was a bold, conventional painting, in black lines, of an outspread hand. The central creases of the palm were represented as descending divergingly from between the first and middle fingers, to the base. This was also characteristic of the hands in another much more elaborately painted shell of the kind, that was found by Mr. George Gause within four or five feet of the bird-painting or altar-tablet. As may be seen by reference to Fig. 4, Pl. XXXIV, this painting represented a man, nearly nude, with outspread hands, masked (as indicated by the pointed, mouthless face), and wearing a head-dress consisting of a frontlet with four radiating lines—presumably symbolic of the four quarters—represented thereon, and with three banded plumes or hair-pins divergingly standing up from it. The palm-lines in the open hands of this figure were drawn in precisely the same manner as were those in the hand painting of the pair of shells found with the ceremonial pack, and the thumbs were similarly crooked down. Upon the wrists, and also just below the knees, were reticulate lines, evidently designed to represent plaited wristlets and leg-bands. Otherwise, as I have said, the figure was nude. It was not until our excavations were well advanced beyond the middle sections of the court of the pile dwellers, that these singular painted shells were discovered, since they were closed when found as were those in the collections that I found under the sea wall at the southwestern margin of the court. Throughout the richer portions of the court which we had already passed over, we had quite generally encountered these closed sun-shells, so many of them, in fact, that we had usually thrown them aside; since we had regarded them as intrusive, as probably the remains of living species that had found their way into the court after its abandonment. Hence I have no doubt that we missed many treasures of this kind of symbolic painting From the small number of specimens we recovered, it is difficult to surmise what could have been the purpose of these painted shells. There is of course no doubt that they were ceremonial or sacred, but whether they were used in Shamanistic processes of divination or not, it is measurably certain that they were regarded as potent fetiches or amulets, for in the one that contained the painting of the outspread hand that I myself found and opened, a substance, which I regarded as decayed seaweed, had apparently been placed to symbolize, in connection with the figurative hand, creative potency; for algæ and the green slime of the sea is regarded by many primitive peoples as earth-seed or world-substance. Unfortunately I did not see the other shell until after it had been opened by Messrs. Gause and Bergmann; but hearing their cheers over the discovery, I ran immediately

to the spot, and had the good fortune to rescue it before attempt had been made to wash it out. For although, as has since been ascertained, the paint employed in its delineation was made from a quite permanent, gummy substance (probably rubber), yet when first found it was almost fluid, like that on many others of the paintings.

When I exhibited this specimen and the drawing of the open hand to Mr. Clarence Moore, whose interest in these finds has been from first to last so gratifying, he kindly called my attention to a concavo-convex or shell-like plaque of stone, found in a mound in southern Illinois, in which an almost identical figure of an open hand was incised. In a shell disc discovered in Georgia, there is, I have also recently learned, an etched delineation of an open hand containing an eye-like figure; and I am therefore the more inclined to regard the sort of shell paintings we found as not only in a high degree symbolic and sacred, but also as typical, and I also incline to believe that they were, moreover, the earlier forms of the etched or graven figures of the kind just described as found in the more northerly mounds.

As evidenced by the exquisite finish and ornamental designs of so many of the implements weapons and utensils I have described, the ancient key dwellers excelled especially in the art of wood-carving. While their arts in painting were also of an unusually highly developed character,—as the work of a primitive people—their artistic ability in relief-work was preëminently so. This was further illustrated in a little wooden doll, representing a round-faced woman wearing a sort of cloak or square tunic, that was found near the southernmost shell-bench along the western side of the court, in Section 15. Near this little figure was a superbly carved and finished statuette in dark-colored, close-grained wood, of a mountain-lion or panther-god—an outline sketch of which is given in Fig. 1, Pl. XXXV. Nothing thus far found in America so vividly calls to mind the best art of the ancient Egyptians or Assyrians, as does this little statuette of the Lion-God, in which it was evidently intended to represent a manlike being in the guise of a panther. Although it is barely six inches in height, its dignity of pose may fairly be termed "heroic," and its conventional lines are to the last degree masterly. While the head and features—ears, eyes, nostrils and mouth—are most realistically treated, it is observable that not only the legs and feet, but also even the paws, which rest so stoutly upon the thighs or knees of the sitting or squatting figure, are cut off, unfinished; bereft, as it were, of their talons. And this, I would note, is quite in accordance with the spirit of primitive sacerdotal art generally—in which it was ever sought to fashion the form of a God or Powerful Being in such wise that while its aspect or spirit might be startlingly shown forth, the powers associated with its living form might be so far curtailed, by the incompletion of some of its more harmful or destructive members, as to render its use for the ceremonial incarnation of the God at times, safe, no matter what his mood might chance, at such times, to be.

Masks and Figureheads.

To me, the remains that were most significant of all discovered by us in the depths of the muck, were the carved and painted wooden masks and animal figureheads. The masks were exceptionally well modeled, usually in realistic representation of human features, and were life-size; hollowed to fit the face, and provided at either side, both above and below, with string-holes for attachment thereto. Some of them were also bored at intervals along the top, for the insertion of feathers or other ornaments, and others were accompanied by thick, gleaming white conch-shell eyes (as in Fig. 2, Pl. XXXIII) that could be inserted or removed at will, and which were concave—like the hollowed and polished eye-pupils in the carving of the mountain-lion god—to increase their gleam. Of these masks we found fourteen or fifteen fairly well-preserved specimens, besides numerous others which were so decayed that, although not lost to study, they could not be recovered. The animal figureheads, as I have called them, were somewhat smaller than the heads of the creatures they represented. Nearly all of them were formed in parts; that is, the head and face of each was carved from a single block; while the ears and other accessory parts, and, in case of the representation of birds, the wings, were formed from separate pieces. Among these animal figureheads were those of the snouted leather-back turtle, the alligator, the pelican, the fish-hawk and the owl; the wolf, the wild-cat, the bear and the deer. But curiously enough, the human masks and these animal figureheads were associated in the finds, and by a study of the conventional decorations or painted designs upon them, they were found to be also very closely related symbolically, as though for use together in dramaturgic dances or ceremonials. On one or two occasions I found the masks and figureheads actually bunched, just as they would have been had they thus pertained to a single ceremonial and had been put away when not in use, tied or suspended together. In case of the animal figureheads the movable parts, such as the ears, wings, legs, etc., had in some instances been laid beside the representations of the faces and heads and wrapped up with them. We found two of these figureheads—those of the wolf and deer—thus carefully wrapped in bark matting, but we could neither preserve this wrapping, nor the strips of palmetto leaves or flags that formed an inner swathing around them. The occurrence of these animal figureheads in juxtaposition to the human masks which had so evidently been used ceremonially in connection with them, was most fortunate; for it enabled me to recognize, in several instances, the true meaning of the *face-paint* designs on the human masks thus associated with these animal figures. I cannot attempt to fully describe the entire series, but must content myself with reference only to a few of the more typical of them.

Near the northernmost shell bench, in Section 20 of the plan shown on Pl. XXXI, was found, carefully bundled up, as I have said, the

remarkable figurehead of a wolf with the jaws distended, separate ears, and conventional, flat, scroll-shaped shoulder- or leg-pieces, designed for attachment thereto with cordage, as shown in Fig. 1, Pl. XXXIII. A short distance from this specimen was found the beautifully featured man-mask sketched in Fig. 2 of the same plate. Now both of these specimens had been painted with black, white, and blue designs, which unfortunately cannot be shown with sufficient clearness in the uncolored sketches. When I observed that the designs on the human mask represented, albeit conventionally, the general features and lines of the wolf figurehead associated with it, I was no longer at loss to understand the connection of the two. It will be observed that on the ear-pieces of the wolf figurehead, are two well-defined and sharp-pointed dark areas representing the openings of the erect ears, and that correspondingly, above the eyebrows of the mask itself, similarly pointed black areas are painted, while the tusked open mouth of the wolf figurehead is also represented by jagged, or zigzag lines on the mask, extending across the cheeks upward to the corners of the mouth, apparently to symbolize the gnashing teeth of the wolf; and even the conventionally represented shoulders and feet of the springing wolf figurehead are drawn in clean white lines over the entire middle of the face of this mask. It was therefore evident to me, that these painted lines upon the human mask were designed, really, to represent the aspect and features and even the characteristic action or spring, of the wolf. Hence I looked upon these two painted carvings as having been used in a dramaturgic- or dance-ceremonial of these ancient people, in which it was sought to symbolize successively the different aspects or incarnations of the same animal-god, namely the wolf-god, —that is, his animal aspect, and his human aspect.

Now this association of the animal figureheads with themasks presenting their human counterparts was not exceptional. In another portion of the court the rather diminutive but exquisitely carved head, breast and shoulders (with separate parts representative of the outspread wings, near by) of a pelican, was found, and in connection with this, a full-sized human mask of wood, also. Upon the forehead, cheeks, and lower portion of the face of this mask, was painted in white over the general black background, the full outline (observed from above) of a flying pelican, as may be better seen than imagined by a comparison of Figs. 3 and 4, in Pl. XXXIII—especially if I explain that the under lip and chin of this man-pelican mask was quaintly pouted and protruded to represent the pouch of the pelican—in a manner that does not show in the full-face drawing.

The remarkable and elaborately carved and painted figurehead of the leather-back turtle; the large figurehead or mask-like carving representative of a bear—its face also elaborately painted—and others of the animal figureheads which we found, were likewise paired or associated with their human presentmentations or counterparts—that is, human masks painted with practically the same face-designs as occurred on these animal figures.

The symbolic unity, or general similarity of painted designs on the masks with human features to the face paintings or markings on the very realistic animal figureheads grouped or associated with them, gave me a new insight into the meaning of mask painting in general, and into the meaning also of even simple face painting as practiced so widely among primitive peoples, especially among such as use masks in their dances or other sacred and dramatic ceremonials. That the interpretations I shall presently venture to offer may seem less far-fetched than otherwise they might seem, I will explain a little more fully, the tendency peoples of this kind have, toward reproducing, in their face-paintings or upon their masks, the characteristic marks or features of animal faces. I cannot better do this than by making a few statements regarding the philosophy of form I was taught whilst living with some very primitive-minded people—the Zuñi Indians—some years ago. Since they observe that life is never manifest save in some sort of *form*, they argue that no form is without some sort of *life*, and since they further observe that each particular kind of life is manifest in some particular kind of form, they argue that form strictly conditions life—its powers and other characteristics. Naturally, therefore, they accord to forms (or rather to semblances) even of inanimate things, such potencies as they see manifested in the forms of the animate beings these things most resemble externally or otherwise. Let me illustrate this. They connect the wave-, or ripple-like scales of fishes with their ability to live and float in the wave-fretted waters; they believe it is chiefly because of the cloud-like down under or between the feathers of a soaring bird that he is able so lightly to fly among the similar, fluffy or downy clouds—for these of themselves like the mist of living breath, ever float without effort. To such a people, of course, form, semblance, aspect, is therefore all important; and they naturally think that by reproducing a given form or appearance which of itself gives rise to a certain effect, they may again and unerringly produce, or help to reproduce the same effect, with the form of their own making.

This sort of reasoning about analogy between form and function, between creatures and the phenomena that resemble their operations, between animals and things, is only touched upon here—just sufficiently to indicate how a people thus reasoning further reason that as the lives, conditions and powers of animals differ as do their forms, so the specific traits or characters of animals differ according as do their differing aspects, especially according as do the expressions of their countenances; and finally, that since the facial expression of each kind of animal is unvarying in all members of the species, and the corresponding trait or character of each is equally unvarying, they reason that expression controls, rather than that it is the result of, character or disposition—so far at least as these animals are concerned. It follows that they believe the changes in the expression of a man's face to be similarly effective. They observe that his face is far more mobile than is that of any animal, and hence believe that he is more capable of changing; that according as his

mood changes, his face changes; and they reason that *vice versa* according as his face is changed his mood must necessarily change. Further, they believe that not only according as his face changes so does his mood change, but also that his traits or his entire character may, for the time being be changed, by *wholly* altering, with paint or other marking, with mask or other disguise, the entire expression of his countenance or aspect. Just as a wrathful warrior, with glaring eye and drawn mouth, and alert or defiant attitude, resembles to some extent a mountain lion or a panther at bay, so by the painting upon his face and upon other portions of his person of the characteristic markings of the panther, he may be made to assume still more fully the nature of the panther.

Now when we reflect that the peoples who reason thus are also in a totemic phase of development sociologically—largely because they do reason thus—that they are inclined, each according to his tutelary deity or the totem of his clan, to emulate the animal (or supposedly living plant or thing) that is his clan totem, in both behavior and appearance so far as possible—in order to become so far as possible incarnated with his spirit—we find one of the many reasons he has for painting his face with the aspect, or face marks, of some special animal. Moreover, in this reasoning may be found a primal explanation for his supposition that by putting on a mask he can more utterly change for the time being; can even change his totem or relationship; can become, to quote rom the Zuñis, "That which he thirsts to become," or "Desirously needs to become, what tho' a God," strictly according to the expression (and name) or aspect, of the mask he makes and marks and puts on. Thereby, it is believed that so far as he resembles in facial aspect or expression one kind of being or animal or another kind of being or animal, he will become that being or animal, or at least, be possessed by its spirit.

Nothing short of a full treatise on this primitive philosophy of analogy, and the relation thereto of maskology or disguise by costuming, painting, tattooing, bodily distortion or mutilation and the like, as a means of becoming actually incarnated with the spirits of ancestors, mythic beings, and animals, or totem gods, would fully explain the significance of the bunched animal figureheads and animistically painted human masks that we found. I may add, however, that one can see how far reaching was this primitive conception of the life-potency of form, or expression, by examining any sorts of ancient vessels that are decorated with maskoids or diminutive representations of human or semihuman countenances. Almost always these maskoids — whether found on mound-builder vessel, Central American jar, ancient Peruvian vase, or even Etruscan urn—are characteristic, according to the style of expression they represent, of some particular kind or use of the vessel they occur on. They have often, indeed, been described as grotesques, caricatures and the like, usually without any further explanation; yet the absence of a humorous conception or intent in their portrayal is demon-

strated by the fact that if we study the relation of the primitive vessels on which they occur to other things, with which, for example, they are sometimes found, we shall speedily discover that each curious mask upon such vessel is but the exaggerated expression of a character or being it was sought to associate in some way—as by fixing its potency—with the "being" and purpose, of the pot itself, and this is especially true of vessels designed for ceremonial use.

A strikingly perfect example of the kind of animal carving I have earlier characterized, was the figurehead of a deer, which Gause and I found near the edge of the northernmost of the shell benches along the western border of the court (in Sec. 22, Pl. XXXI). It was lying, in a very natural position, on its side. Thus seen in the midst of the dark muck, its light-hued painted lines vividly revealed by contrast, its large, deep brown eyes wide open and lifelike—for the pupils were formed of polished, cleverly inserted discs of tortoise shell—it was the most winsome and beautiful figure of the head or face of a doe or deer that I have ever seen, albeit so conventionally treated. The illustration of this figurehead shown in No. 2 of Plate XXXV, by no means does justice to the graceful lines of the original carving, or to the fineness of the painted decorations thereon, for the view is too directly full-faced. The earpieces had been attached to the back of the head by means of cords passing over pegs thrust through them and then through bifurcated holes at the points of attachment to the head-piece, in such manner that they could be used as pulleys for the realistic working of these parts; and the unpainted edge, as well as peg-holes all around the rearward portion of the head, plainly indicated that the skin of a deer or some flexible substitute therefor, had been also attached to it, the more perfectly to disguise the actor who no doubt endeavored in this disguise to personate the character of the deer-god or dawn-god, the primal incarnation of which this figure was evidently designed to represent.

A mask of purely human form was also found not far away. It had evidently been associated with the figurehead in such ceremonials as I have referred to. At any rate, like the figurehead itself, it had over the eyebrows a crescent-shaped mark—which seems, by the way, to have been the forehead-symbol of all sorts of game-animals amongst these people, as betokened by its presence on the forehead of the rabbit carving and of other similar animal carvings. It also had the tapered, sharp-pointed white marks or patches along either side of the nose above the nostrils, observable on the snout of the deer head, and the four sets of three lines radiatingly painted around the eyes to represent winkers. This latter characteristic in the eye-painting of the deer figurehead, is very noteworthy; for it would seem that it was intended to symbolize, by means of the four sets of three lines, not merely the eyelashes of the deer, but also rays, of the "eye of day" or the sun. This I infer the more unhesitatingly because, according to the accounts given by more than one early writer on Florida, the deer must have been regarded

among some of the Floridian tribes as one of the gods of day or of the dawn—as indeed is both the antelope and the deer among the Zuñis. In such event they symbolized—just as do similar sets of radiating lines around paintings of the Zuñi sun-god—the four sets of the sun's rays that are supposed to correspond to the four quarters of the world, as well as to the four sets of three months in the corresponding four seasons of the year over which the sun god is believed to have dominion—since he creates all the days thereof.

Not only were the human masks associated with their animal counterparts, but sometimes two or more of the human masks were found in one such group. In two or three instances we found multiple sets of them. In such case they were superimposed, as though they had been tied or wrapped, one inside of the other, and thus hung up or laid away, and had fallen so gently into the water-court that their relation to one another had not been disturbed thereby. A notable example of this kind was found in the association of two masks—one lying directly over the other, the faces of both turned upward—that lay not far away from the turtle-figurehead that I have already described. The painted lines on the lowermost of these masks were indicative that it was designed to represent the man-turtle or man-turtle god; whilst the lines upon the superimposed mask seemed, from their general resemblance to the face marks painted upon the bear-figurehead I have also described, to indicate that they were designed to represent the same sort of human presentmentation of the bear. I am at loss to account for this singular consociation of the two masks—the turtle-man mask and the bear-man mask—unless by supposing that the ancient people who made them, regarded the somewhat sluggish turtle as the "bear of the sea," and the bear, whose movements are also awkward, as one of his "brother-turtles of the land," or that they otherwise mythically related them.

We found several human masks by themselves. One was clearly, from the length of its sharp nose and the painted lines upon its features, designed to represent the cormorant; another, from the oblique or twisted form of its mouth, its nose awry, and its spiral or twisted face-marks or bands, as plainly represented the sun-fish or some other slant-faced fish. I regarded a third one of these masks as that of the man-bat-god. It was of especial interest, not only on account of its associations, but also on account of its general resemblance to the face of the bat-god of night conventionally depicted so frequently on Central American monuments. Still another mask was of equal interest, for it represented unmistakably, in a half-human, half-animal style, the features of the wild-cat; and the curiously doubled paint lines with which its cheeks were streaked downwardly below the eyes, although strictly regular and conventional, were singularly suggestive of the actual face-markings of the wild-cat, and thus enable us to understand the significance of like lines that are incised upon certain purely human-faced figures characteristic of many of the maskoidal pipes from mounds of the Ohio and Mississippi valleys.

I would once more call attention to the association in *groups* or *sets*, of the animal figureheads and especially of the masks, as affording still further proof of similarity, if not identity, in key-dweller art and mound-builder art, and as thus affording also a satisfactory explanation of certain points observable in delineations I have so often heretofore referred to as occurring upon the shell gorgets and copper-plates of the ancient mounds of Georgia and other Southern States. Almost always, in these delineations of the mythic human figure, it may be observed that while upon the face, a mask is plainly portrayed, yet, in one or other of the hands is as distinctly represented another mask—not a head, as has frequently been supposed,—and I am therefore inclined to believe that, as with the key dwellers, so with these peoples of the mounds, dramas representative of the transformation of gods from animal into human form, and from one human character into another human character, were probably attempted in their sacred dances.

Such a figure of the mound plates as I have described is shown in No. 3, Pl. XXXV, of the accompanying illustrations. It is drawn from one of the celebrated copper-plates of the "Etowah Mound" of Georgia, and I have reproduced it here (from one of Prof. William H. Holme's superb drawings) not only to illustrate this statement regarding the probable ceremonology of duplicated masks in both cases, but also to illustrate various other points of close similarity between the art remains of the two peoples. The so-called baton, held in the right hand of the figure in this plate, may be seen to correspond very closely to the war-club which we discovered in the court of the pile dwellers, and which is outlined in front thereof ("a," of the same figure). It may be seen, too, that the winged god here portrayed wears not only a beaked mask, but also a necklace of oval beads, and an elongated pendant depending therefrom, like those we so frequently found; an ear button, also exactly like those we found (shown in "d" of the same figure): that around the wrists, arms and legs of this primitive portrait are represented reticulate or plaited bands, as around the wrists and legs of the figure painted in the sacred shell I have described ("b" and "c"); and that finally, this character bears in his left hand a mask, the face lines and ear plug of which as closely resemble those that we actually found (as shown in "e" and "f" of the figure) in the court of the pile dwellers.

General Conclusions.

In reference to the general significance of these observations and finds in southwestern Florida, I must necessarily be brief, since this paper has already reached a length that was not, when I began, contemplated.

As to the origin of the key-dweller phase of existence, it was, I think, so much influenced by certain coastal conditions, that a few words on

the physiography of the Lower Gulf section of Florida which best exemplifies them, will not be amiss.

The whole coast, even from as far north as Tarpon Springs to the extreme end of the Peninsula, is low and sandy; the highest natural land rarely rising more than a few feet above high-tide level, and the loftiest dunes nowhere reaching an altitude of over fifty feet. Geologically, Florida, Prof. W J McGee tells me, is an extension of the lowland zone—made up of later mezozoic and cenozoic deposits—fringing our Atlantic and Gulf coasts, and, as one of your Secretaries, Dr. Persifor Frazer, also states, reappearing in several of the Antillean islands. Especially do the prevailing formations of Florida resemble those of the Peninsula of Yucatan. They are of very pervious limestone, and from above the region of Charlotte Harbor southwardly, are interspersed with phosphatic beds, also of organic origin. But whether indurated, as are the lowermost, or less solid as are the more superficial, these formations are, like the overlying soil, excessively sandy. Hence they are not only pervious, but also, very soluble in the acids of fresh surface- or rain-water. One of the consequences of this is, that areas of varying extent and in lines generally parallel with the courses of the open rivers and inlets of the country, and of their tributaries, are subject to undermining by these corrosive processes; have fallen in, forming first deep lakes, then, as these in time have become filled, morasses, in the central lagoons of which, through the peculiar habits of alligators and other aquatic creatures, circular mud-banks have been thrown up, becoming cypress islets, and, finally, the foundations of hammocks, or marsh-keys like those of the Anclote region—built there by man in later ages. Everywhere, too, along the lines of narrower subterranean rivers formed by more restricted dissolving away of the underlying formations, series of perfectly round, hopper-shaped sinks occur, seemingly fathomless, containing pellucid or deep green water, and reminding one measurably, not only of the round, artificial drainage basins of the keys, but also of the more natural (and in some ways identical) çenotes or ancient well-caves of Yucatan and other portions of Central America.

Not to enter as fully as I ought into a discussion of the physiography of this inner portion of the coast—so suited to settlement by a people like the key dwellers, when they came inland—I may say that the conditions described render the whole region peculiarly unstable. This has been especially true of the actual coast. Everywhere it is indented by such tidal inlets as the Manatee and Pease, or their sluggish inland extensions called rivers, like those of Anclote, and those that put out from the north and east of Charlotte Harbor, and those which everywhere radiate sinuously in the same general directions, from the great indentation or bay that contains the Ten Thousand Islands. In a land so broken and low as this, the hurricane has wrought continuous change of shore-line, and 'tis but natural, too, that its coast should be skirted

by wide reefs, paralleled by long-reaching, sea-enclosing, narrow, tide- and wind-heaped sand-islands such as already described; and that all its hither shores should be nearly tide-low, traversed by forbidding marshes, and fringed by almost impenetrable swamps of cypress and mangroves. Even the mouths of its creeks, rivers and inlets, are shifting and treacherous, and are also filled with shoals, almost if not quite exposed, at low tide. As a consequence, approach, even in light craft, is —save in special places sundered by many miles of unnavigable shallows—wellnigh impossible. I regard this feature as having had a preponderating influence in causing the ancient key dwellers—whether they were derived from the mainland or whether, as I have reason to think, they were alien comers to these shores from some distant region over the sea,—to locate as they did, out in the midst of the open waters.

Again, no waters in the world so teem with food-producing animals —mollusks, fishes, crustacea and turtles—as do these waters of the lower Florida Gulf-coast. Yet to a people dwelling inland—save in such favored, far-sundered sections of the country as I have mentioned— this abundance would be all but valueless, in consequence of the difficulty of shoreland navigation. What more natural, then, than, as I have endeavored to picture in earlier chapters of this paper, that these peoples should have followed the example of the pelican and cormorant, and located their stations for food-winning, and finally their dwelling-places themselves, out in the midst of the navigable, but still not too deep, shoreland seas? That they did so, ages and ages ago, is unquestionable. That the structures which they reared, more or less modified, in many cases, the further distribution of shoals, sand reefs, tidal swamps and the lowlier of the fringing islands themselves, is also unquestionable—as I might proceed to show by entering into a discussion of the results of my investigations of certain of the keys that, although once free islets, are now connected with the capes of the outer islands; and of certain others that have, in fact, been almost buried in sand-drift, as was the Ellis Settlement. But suffice it if I say that not only have wide stretches of sandy shoals drifted up between all the humanly constructed reefs of the olden time that lie near the land—especially those to the south—but also, that wide mangrove swamps have grown up around them, as among the Ten Thousand Islands, evidencing the vast antiquity of the earliest key-building and key-builders here.

There are, however, other evidences of great antiquity, more directly of interest to us as anthropologists. One of these evidences is manifest in the character of the art displayed on all of the more finished objects we found in the keys; for this was of a highly, and at the same time distinctively conventional kind. Now I scarcely need state of primitive art-forms, that wherever they have obviously originated and have become highly conventionalized in, and yet are still recognizably characteristic of, a peculiar region—to the degree to which those of this art were character-

istic of the environment we found them in, they are the product of a *very* slow growth. Certainly, while this art of the keys may not have been, nay, was not, altogether of a strictly local origin, it was in the main, of a kind which one might expect to find developing or developed in such an environment. Everywhere, for example, evidence of the influence of shell, shark-tooth, and other sea-produced materials—used as implements in the working of wood, bone and horn, and of shell itself—could, as I have shown, be traced here; and had plainly, as I have also shown, given rise to special ornaments on particular parts of things thus made. But the point of interest is, that these ornaments were not only conventional, but that they had already become conventionally *specialized;* were, many of them, indeed, so highly conventionalized and thus so specialized, that except for the completeness of our series, they could not have been traced to their simple, incidental origin in the kinds of tools used, modes of working employed, and materials worked. I have said that this kind of conventionalization in art and localization of decorations, is of exceedingly slow growth. This is because generations, if not ages, are required for the radical modification of a single specialized ornament on any particular part of a specialized tool or implement, weapon or ceremonial appliance, among primitive peoples; owing to such peculiar conceptions of the meaning and potency of form as I have already discussed in its relation to ceremonial objects, and will presently again refer to as particularly relating to things practically used. By way of a single example, I may instance the circular obvolute, or navel ornament (as I have called it), in its relation to the ends of the hard-wood handles of certain classes of tools in the collection. I have referred to this as having been derived directly from the double spiral or obvolute observable on the cut-off apices or ends of conch- or busycon-shells and other univalvular shells. I have also suggested that the use of kingfish jaws and shark-tooth knives in girdling sticks, by a process of cutting around and around the sticks always in the same direction, with these sharp, yet jagged tools, produced, as shown by many specimens in the collection, rough, spiral rosettes at the ends of the sticks. Now when the sticks were severed in the same way, but first from one side then the other, the figures produced at the ends of them strikingly resembled the involuted spirals at the ends of the worked shells. Thus, although the figure when associated with purely ceremonial objects doubtless signified the "navel" or "middle"—as earlier suggested—yet it came to be associated also with the ends of the handles of tools the working parts of which were made of the columellæ of shells on the ends of which it naturally occurred. Thus, for mythic reasons, the figure was doubtless considered not only appropriate, but even essential to the handle, no less than to the shell armature of such a tool, in order to harmonize its parts, to give potency or effectiveness to it as a whole. So too, with the radiate or rosette figures found on the ends of very small handles made from saplings. It was observed that when suitable

saplings were cut off squarely and sufficiently smoothed, little check-lines, such as one may see on the sawed-off end of a seasoned stick, always appeared, radiating from the heart toward, but not quite to, the circumference of the severed segment. Thus the figure came to be exaggerated decoratively, and associated with the end of another special kind of working tool and, for like mythic reasons, was retained. The steps by which these originally half-natural or accidental markings became developed as decorations, then localized on special tool-handles, and then so characteristic of special types of tools as to be laboriously reproduced even in other material than wood—like the horn and bone sometimes substituted therefor—could only have been taken very slowly.

Still more confidently may this be affirmed of the art displayed on objects less evidently of local origin, for they illustrated an equally slow and much longer continued process in the development of conventional art, that of survival—as on the box-tablets described; which, being no longer held together with double cords or strands lashed around them and tied over their middles with square- or reef-knots (double figure of eight knots) had come to be secured with gum and pegs, yet must still be mythically tied with *painted* strands and knots in imitation of the "good old way." In this connection I would again refer to the superb celt-handle, the decorations on which were so very highly conventionalized and so modified by the introduction of shell-volute figures and of certain eye-marks derived from knots (the one kind of figure being generic on the shell tool handles just referred to, the other on the crooked adze handles, as shown in Fig. 2, Plate XXXII), that it was with difficulty the main lines and bands on the shaft and head could be recognized at all, as survivals of the wrappings or bindings on simpler and earlier forms of this kind of instrument.

If these forms of decorations on tools, and their association with special parts thereof—whether of extraneous or of autochonous origin, possessed as they were, of so high a degree of conventionalization—were of great age in development, this must to a much greater extent have been the case with the yet higher degree of conventionalization shown in the representation of face and body marks on animal carvings and paintings in the collection. In the first place, these marks on, for instance, the faces of the figureheads, were not irregular, as they are seen to be on the faces of the natural animals they represented. While the forms of these figureheads were realistic to a degree, the painted or incised face marks were remarkably conventional, regular, and almost perfectly symmetrical. That is, stripes were represented as clean bands, patches or spots as neat circles or figures, sometimes elaborated into highly ornate curved devices. Yet as a whole, these painted or incised face markings were so distributed and contrasted as to look startlingly natural when seen at a distance. To give an idea of the great degree of conventionalization thus attested, I have only to state that this kind of highly artificial and ornate representation of the face markings of animals be-

tokens an attempt on the part of the primitive artist to represent the *ideals*, the perfect ancestral types or spiritual archetypes, of the animals portrayed—for it is supposed, as is told in the numberless beast-tales of his people, that the present animals, descendants of these great and perfect ancestors, have been changed by their own deeds, their disobedience of the gods, their strifes and what not, and that thus their countenances are distorted or besmirched, and fixed so in token of their rashness or misfortunes in creation time. So this kind of conventionalization represents myth, as well as art; both, developing and interacting uninterruptedly throughout a very long period of progress in a given organic environment. If this be true of the *style* of the art, it is doubly true of its *symbolic specialization*. For it has been seen that in case of the figures of timid creatures—game-animals, like the figurehead of the deer, the carvings of the rabbit and other creatures of the kind—all were characterized by a crescent-shaped device on their foreheads. Thus, this conventional mark was not merely that of an individual representative of the species, but it was, so to say, a generic mark, representative of several species of the same general kind. This is further shown by the fact that another special kind of marking was equally characteristic of animals of prey—of the wildcat, the panther, the bear and their kind. In the carvings of each one of these fierce creatures, the outlines of the eyes were not only sharply pointed in front but in each case terminated behind in three sharp triangular lines or marks pointing backwardly, and giving to the face of the animal figure a peculiarly crafty, yet sinister look. That this too was a generic mark, is still further indicated by the fact that it occurred also upon one of the human masks corresponding to the figurehead of one of these fierce creatures. Now in this generic kind of marking we have not only a still higher art development, but also a very much higher mythic development betokened, since it indicates that these ancient peoples regarded the game-animals as of one great family or descent, and the prey-animals as of another great class or lienage, and that they were thus, in a way, naturalists of no mean order.

The interest of the significance of this particular sign of the eye as pertaining to or symbolizing prey-beings, is enhanced greatly by the further fact that upon many of the exquisitely finished and highly conventionalized carvings of the heads of these kinds of beasts (and of the faces of warriors or men wearing masks animistically corresponding to them as well) that are found so frequently in the mounds of the Mississippi Valley, of Tennessee and even of Ohio, precisely the same conventional marking or barbing of the eye—as though it were set in the figure of a stemmed and barbed arrow-point to make it "piercing"—is observable. Thus, through a study of the conventional treatment of such figures here in the keys of lower Florida, we not only arrive at an understanding of a new meaning of these figures or lines around the eyes of maskoids and head-carvings found in the far away north (namely, that they represent animals of prey or their human counterparts), but we also see that the same

art was, in these widely separated regions, so identical in this particular, that we cannot but assign to it a single cultural origin. That is, we must look upon it as having originated in one or the other, the northern or the southern portion of the area throughout which it was so generally distributed; as having spread from that single centre in the one or the other direction. Now the bulk of evidence at hand favors the belief that the place of origin of the peculiarities I have noted, was here in the far south; probably, among the keys.

Be this for the moment as it may, the enormous distance to which these characteristic art forms had spread after long-continued and full development, must have required a still more enormous length of time. This is a further and a much more impressive indication of the very great antiquity of the art in question. For the spread of special art forms in definite relation to particular implements or figures is, among primitive peoples, not so frequent or facile as is usually supposed; and when in rare cases it does occur, it is effected with exceeding slowness. We may account for the spread of arts among primitive peoples in two ways; first, by barter and intercourse, conquest and adoption; or, second, by actual derivation or descent, that is, by actual spreading to a greater or lesser extent, of the people among whom the art prevails and originated. While we may hold that, in the wide diffusion of arts common alike to the keys and the mounds, both of these causes acted to some extent, still, if we consider a little further the way in which arts spread among primitive peoples—why slowly—we can, I think, arrive at a more definite understanding of the question as to which of the two causes above stated was the more active, and as to whether the art traveled from the Gulf northward, or from the north southward. First, then, the mere fact that early peoples attribute to distinctive forms particular existences and potencies, indicates that one people would be slow to adopt unchanged from another, an unaccustomed form, even of so simple a thing as an implement, and especially as a weapon or a ceremonial object; since the unaccustomed form of the first would be supposed by them to render it inefficient; of the second, unsafe; and of the third, diabolical; while all would be held to be unsuited, because unrelated to themselves. It must be constantly borne in mind that these ancient theorists believed their implements and weapons and amulets to be alive, and felt that the powers of these things were not only strengthened, but were also restricted to or rendered safe for, special uses, as well as made to be related to their *makers*, by their forms or by the decorations or figures placed upon them, especially when these were highly symbolic. It is for this reason more than any other, that primitive peoples cling so to forms, and are so chary of borrowing new forms of implements or weapons, etc. When they do borrow the fashions of such things, they proceed at once to cover or invest them with the peculiar decorative or symbolic devices that they are accustomed to associate with the same kinds of things in time-honored use

among themselves. It is chiefly due to this tendency that we have kept inviolate for us everywhere in the primitive world, signs on the relics we find, of what have been termed cultural areas or areas of art-characterization. And so, while the extensive and long-continued intercourse in the barter of the far-southern peoples of Florida and the keys, with more northern peoples (which is so positively indicated by the occurrence in the northern mounds, of gorgets, etc.—not only derived from species found nowhere else than in these Gulf regions, but also treated in precisely the same conventional manner), will account for much in this spread of identical art forms, nevertheless it does not, I am inclined to think, explain the whole. To say for the moment nothing further of the great variety of art forms which almost certainly took their origin in the region of the keys or in some other Gulf region where a life of similar kind was naturally or necessarily followed, and which are also found throughout the mound area, I may call attention to a single point among many—the evidence afforded by the tempering-material of pottery. Almost always, the pottery of sea-dwelling peoples, in regions where clays of such kind as require tempering occur, is tempered with calcined and crushed shell. In an article on "The Germ of Shoreland Pottery" (printed in the *Memoirs of the International Congress of Anthropology*, pp. 217–234, Chicago, The Schulte Publishing Company, 1894), I have endeavored to show why this is so, and was at first naturally, if not inevitably so. Now, wherever the art forms I am discussing are found in the mounds, even at far inland points, the potteries of these same mounds are commonly tempered with shell, notwithstanding the fact that in the more inland and northerly regions of the mounds such kind of tempering had to be supplied, at great labor, from fresh-water species of mollusks.

There are, however, various additional reasons, it seems to me, for supposing that this art spread northwardly from a southern sea-environment —not so much by barter, as by actual movement landwardly and northwardly, of the culture and to some extent of the peoples themselves of these southern sea-land regions. One of these reasons rests in the very broad distinction that we may make between the sea-shell art of the mounds and the sea-shell art of other and more northerly regions, equally as far inland from the sea. There, objects made from sea shells are abundant, it is true, but they are in general, obviously of a more purely decorative or valuative, than of a symbolic character. This was the case, for example, with the famous wampum of New England and the Middle Atlantic States, prized for the high value of the far-derived material of which it was made, more than for its supposed sacred or ancestral qualities; whereas, the greater number of the shell cups, gorgets, and other shell articles found in the mound region proper, retained the identical pristine symbolic character and association they naturally had on the seashore. Now it is not easy to see how this could have been the case had the peoples of the mounds originated, or rather had their culture,

customs and art originated, in the northern or inland region, and proceeded thence to the sea.

I would again mention the wide prevalence in the keys, of the distinctively conventional treatment of carved and incised work,—whether on shell, bone, or stone,—illustrated by so many specimens in our collection, in connection with its almost equally wide prevalence on figures found in the mounds; which art-vogue was, it would seem, more at home in the keys—more in accordance with a seaside environment that appears to have originated these conventional forms and modes of treatment—than in the lands of the north. The identity of costume represented, too, in the case of the painted shell as compared with incised shell gorgets and embossed copper-plates of Tennessee and Georgia, is obvious, as may be seen by reference to the single illustration herewith furnished in Pl. XXXV, Fig. 3.

It is significant that the forms, as well as the surface decorations of the potteries which we found somewhat inland, in the more northerly region of Tarpon Springs and of the Anclote (and this applies also to shoreland-like examples of pottery that I have seen from the still further interior and more northerly portions of Florida, and even from western Georgia) were in many ways distinctively and indisputably derived from precisely such gourd- and woodenware and shell-shaped vessels and utensils as we found in the keys. It was thus obviously the pottery of a people who had been accustomed to use gourd-shells and wood, more than clay, for the making of their vessels, and not only so, but to use wooden vessels that had been made with cutting implements of shark-teeth and shell. This was clearly evidenced in the hachured surfaces of so many of the vessels; in the reticulated surfaces of others of them—which represented the end grainings of wood—and in the fine, convoluted or concentric, stamped or incised designs obviously derived from curly-grained wood or paddles made thereof, which characterized the surface decoration of so much more of this pottery. When we add to this the fact that here in the North and in the interior, the points of many blades of flint were made not only in the usual lanceolate or leaf-shaped form, but also in the asymmetrical form of shark's teeth, and that now and then even exquisitely polished stone adzes were formed as obviously in imitation of naturally curved shell adzes—such as were constantly found in the keys—it is perfectly evident that the peoples who built up, in the marshlands here, the hammocks, and built near them the little lake-encircled mounds, were originally a people of the sea, not of the mainland, were a people who had once lived as the key dwellers-lived, on island mounds in the sea or its shoals, here using such implements as their ancestors had there used, and carrying ancestral ideas of habitation and of utensils down from generation to generation, and so, slowly up into the land.

The theory I have ventured to advance heretofore, in regard to the relation of key building in the sea to mound building on the land strongly

supports the evidence just adduced as afforded by the correspondence of these potteries and other art remains from mounds in the North, to the art types of the keys in the South. No other theory of the origin of mound building in general, thus far advanced, especially of mound building as it was practiced in the Mississippi and Ohio regions and all through the Southern States, accounts, it seems to me, so satisfactorily or so directly and simply, for the origin of this remarkable practice. We have seen how, for many reasons, it was necessary for the key dwellers to build their mound-like homes or islands, out in the seas. Thus were they near their chief source of food supply; thus were they freed from the almost insupportable pest of mosquitoes and other insects of the subtropic marshy mainland;* thus were safe from any human enemies they might chance to have; and building as they did, special mounds upon these shell islands of theirs for the foundation of special kinds of structures—temples, storehouses or public buildings, places of resort in danger—they were not only protected from the terrific hurricanes and tidal waves that sometimes swept the Gulf seas, but also, I conceive, they developed the habit of erecting great mounds for special structures of this kind to such extent, that it became fixed; so customary traditionally, that whithersoever they or rather their descendants went thereafter, they continued the practice as an essential tribal regulation. At least we find evidence enough in nearly all the old historic records from the Sixteenth to the Eighteenth century, that generally the Southern Indians (especially the Maskokean Indians and Nachez) were still building mounds of precisely this kind, that is, for the temples of their Priests and for the dwellings and assembly places of their Mikos, "Suns" or King-like Chieftains. Again, along with the development of key and mound building for the living, in the sea, and later in tide marshes or lowlands, we have seen that there was also developed, through ancestralism, the habit of building somewhat similar places for the tribal dead. This also was practiced in the interior, as shown by prehistoric monuments; by the early tribes of the Southern States, as equally indicated by

* Soon after my return from Florida, last spring, Dr. O. T. Mason, of the United States National Museum, kindly called my attention to the following passage, on page 291 of *The History of the Caribby Islands*, rendered into English by John Davides, in 1666, from an earlier work by Rochefort. I quote it here in full, as it so unexpectedly confirmed my previous inference relative to the only really important influence of the mosquito as a factor in human progress, that I have ever learned of. Speaking of the Caribbeans, he says:

"Their habitations are somewhat near one to another, and disposed at certain distances, after the manner of a village; and for the most part they plant themselves upon some little ascent, that so they may have better air and secure themselves against those pestilent flies which we have elsewhere called *Mesquitos* and *Maringoins*, which are extremely troublesome, and whereof the stinging is dangerous in those parts where there is but little wind stirring. The same reason it is that obliges the *Floridians*, beyond the Bay of Carlos and Tortugnes, to lodge themselves for the most part at the entrance of the sea, in huts built on piles or pillars."

I would add that the last clause is especially significant in connection with our discoveries in the "Courts of the Pile Dwellers."—F. H. C.

narratives of the first explorers. Thus, especially throughout the mound-building area—primarily in the lowlands of the Mississippi and tributary rivers, then on higher land along these, and finally on the terraces, and even the plateaus of rivers in the still farther north—we find almost always these two kinds of mounds associated; that is, so-called "Temple" and "Domicilary" mounds, and the tumulæ of the dead or "Burial mounds;" and I believe that wherever these two kinds of mounds are found thus associated (as they were naturally and necessarily associated in the keys, and as we have seen that they were associated historically in the Southern States) the evidence is that they were the works of peoples who were either themselves derived from the southern sea islands, or who derived thence their culture, and, if so, a portion at least, of their ancestral population.

Observable facts in regard to mound building of this kind the world over, support this theory of its origin in *sea environments*. Since the subject is so important, I may enlarge upon it by calling attention to the fact that everywhere, the principal builders of mounds, barrows and tumulæ, have ever been maritime peoples, or at least peoples living along great rivers of the sea. Such were the heroic seafaring Greeks of Homer's time, the roving Vikings of Scandinavia. In fact everywhere —and this applies especially in countries famed for the size and extent of their prehistoric shell heaps—the story is much the same; that old peoples of the sea seem ever to have sought to lift themselves or their dead above the tide and flood; to build, as it were, islands even on high land, wheresoever, in the course of ages, they happen to have here and there penetrated into the interior, or else to build foundations like to the refuse heaps of their ancestry, for the priests and other revered personages among their living.

As bearing intimately upon this question in its relation to such ancient remains of our own land, and particularly to the earlier historic Indians of the Southern States (who, as I have said before, were builders of mounds for the support of their public structures), I may here refer to the remarkable statements contained in some of the early writings, regarding others of their characteristics.

It has been seen again and again, that surrounding all the ancient keys, were shell-bank enclosures approached by canals that had, presumably, been used as fish-pounds or -preserves. It goes far toward establishing my theory of the derivation from the key dwellers, or from peoples living practically their life, of some at least of these Southern mound-building peoples, when we read in the narrative of the expedition dition of Don Hernando de Soto amongst these same peoples (1539–1541), presented by the Knight of Elvas to the Spanish King and Council of the Indies, that "On Wednesday, the nineteenth day of June, the Governor entered Pacaha, and took quarters in the town where the Cacique was accustomed to reside. It was enclosed and very large. In the towers and the palisade were many loopholes. There was much dry maize, and

the new was in great quantity throughout the fields. At the distance of half a league to a league off were large towns, all of them surrounded with stockades. Where the Governor stayed was a great lake near to the enclosure, and the water entered a ditch that wellnigh went round the town. From the River Grande to the lake was a canal, through which the fish came into it, and where the chief kept them for his eating and pastime. With nets that were found in the place, as many were taken as need required; and however much might be the casting there were never any lack of them."

Now since the very origin of key building was directly related, in all probability, to the improving of natural, then the making of artificial bayous to serve as fish-pounds; to the building of fishing stations near by, and resultantly, to the construction of shell settlements in place thereof, we cannot reasonably suppose that the key builders derived all this from the mainland, but rather that the dwellers in the interior here spoken of by an eye-witness, had derived their practice of making such fish canals and preserves, from them or from ancestors like them.*

If, then, the key-dweller and Southern seashore and flood-land phase of life and art was, as is here indicated, the originative, the earlier phase, and the mound-builder phase was the later or to some extent inherited phase, it does not follow that the mound builders acquired their art and culture from the *particular* key dwellers the remains of

* To state my opinion clearly in reference to this question of the relation of the mound builders to the particular key builders the remains of whom we investigated, I may say that I do not believe this relation to have been necessarily direct, however much it may seem to have been so. The remarkable correspondence in the art characteristics of the mound remains proper, when compared with those exhibited in objects of our collections from the keys of the farther south, signifies to my mind, primarily, that the art displayed in objects from the inland mounds was inherited or derived from key-dwelling or sea-dwelling methods of technique and art treatment. This (leaving out all other questions) is indicated by numerous examples of mound art. I need mention only two or three. One is exemplified in the double-bladed battle-axe type of war club, figured in Pl. XXXV (3, a). The club of this type that we discovered at Marco was wholly of wood, yet it was evidently, as I have hitherto stated, a survival of the double, semi-circularly bladed war-axe of an earlier time. But it was, nevertheless, a practical, not merely a ceremonial, weapon. Now such a weapon is represented on the embossed copper plates and is engraved repeatedly on the shell gorgets of the mounds, as held in the hands of purely *ceremonial* figures. It is also sometimes found represented (among mound-remains, but not among those of the keys) in the shape of small amulets wrought of shell or stone. Again, a single nearly full-sized specimen, made wholly of stone, rather than of wood, (it is beautifully fashioned from light colored flint by chipping and battering, then grinding and polishing) has been very recently secured, I understand, by that fine authority on mound archæology, General Gates P. Thruston, President of the Tennessee Historical Society of Nashville, Tenn. All of these mound forms of the weapon, however, are strictly ceremonial: that is to say they are not directly *originative* forms, but forms of the weapon inherited and ancestrally venerated, that is, *derived* from some older form still adapted to *practical* use—as was the specimen we recovered from Marco. The same may be said of the shapely carving in green-stone, of a nearly full-sized, hafted celt—found in a sepulchral mound in the Cumberland Valley near Nashville, Tenn., some years since, by Prof. Joseph Jones—the correspondence of which as a type form, to the *actual* celt, found by us at Key Marco, is almost exact, save in merely decorative details of the handle.

whom we investigated. It is simply an indication, I think, that they derived it from like sea-dwelling people—very probably related to such key dwellers, and who possibly had their home farther up the Gulf. Not only are there at present other keys extending, interruptedly, from Tampa to the northwestern extremity of Florida, but between that point and the Delta of the Mississippi is also another very considerable group of islets which I regard as keys—judged by their distribution on the map. Whether they are actual shell keys, or not, remains to be determined. But the formations of the lower Mississippi are late Quaternary. Thus, in comparatively recent times, geologically speaking, we may assume that the area they cover was a northwardly extension of the Gulf, and that for ages later, conditions like those presented by the southern marshy shorelands into which the key dwellers seem to have ultimately penetrated must have prevailed, even unto comparatively recent times, anthropologically or historically speaking. The coast farther down was shoal, and fringed with islets—some, possibly, artificial. Thus the whole region was still suited to such modes of life as I have referred to, even well on toward modern times. And so, from this point of view, the Gulf shore and its border lands to the north and the northeast, no less than farther down, seems to have been as much an *area of characterization* as that of the keys we examined certainly was—of the southern and farther northern mound-builder culture. Therefore my claim is, that the best and most primitive, that is, originative illustration of this that we have, is to be found in these key-dweller remains. I must not be understood, however, as claiming that the mound-builder phase of culture pertained *wholly* to descendants of the key dwellers or even of sea peoples like them. Cultures belong less, primarily, to distinct peoples than to distinct environments. An environment and the essential conditions of human existence therein, makes indeed, not only a culture, but goes far toward making a race; that is, toward moulding or unifying, racial traits, in whatever kind of man or kinds of men come into it and there remain for a sufficient length of time.*

I believe the relationship of the key dwellers to other Southern Indians and to the more ancient mound builders, both in the South and in the farther North, may, however, be regarded, as indicating more than merely parallel development; that this relationship may be considered as having been actual, and accultural, as well as primarily environmental; for the whole region of the mounds, which generally corresponded to the great flood-plain regions of the Mississippi and its mighty tributaries—and in this was not unlike the shorelands of the Gulf—

*If one but glimpse at the natives of like low sea-lands, of let us say, Borneo, Papua, Southeastern Asia and certain Polynesian regions, he will see how close a parallelism in arts—and probably, too, even in institutions and religion—obtains between the key dwellers as indicated by their art remains, and these peoples not in any wise related to them. He will see that merely by a similar condition of natural surroundings, these parallelisms have been wrought to a point that is, in many details of the products of these wide-sundered peoples, no less than astounding.

possessed throughout, also, much else in common, particularly in the matter of biotic characteristics, plant and animal life as they prevailed in at least the marshy borders and immediately contiguous lands. Such characteristics, since so intimately associated with subsistence and art activities, are of course the most potent of factors in giving direction to the movements and developments of primitive peoples,—especially when combined with generally like physical conditions throughout a given area,—and go far in themselves toward making thus, a distinctively *ethnic* area. Let me offer an example of this: In its way, the arid region of our farther Southwest, is more distinctive than is the region of the Southern seas and great contiguous rivers and flood-plains. That is, it is a region the climatic conditions of which are so homogeneous and so pronounced throughout, and the flora and fauna of which are therefore so uniform, that it has been potent to mould into or toward a common condition and type, and a common state of mind, too, nearly all the peoples who have ever entered it and therein dwelt long enough. In the centuries of a far-off time, it presently made of little bands wandering and seeking refuge in its desolate wastes—seeking throughout them for water and seeds—petty agriculturists. It forced them as they throve apace, to permanent occupancy, then to cultivation of, these far-sundered watering-places; then, later, through contentions over these places and possessions, with other comers or with one another, to occupancy of and building in the cliffs, for defense. Thus out of such hard conditions was born the famous Cliff Dweller, his architecture, and his culture. It was my good fortune, years ago, to first definitely relate the Zuñi Pueblo Indians, linguistically and traditionally, with these ancient denizens of the cliffs, and to ascertain positively, and announce in various publications (especially of the Bureau of Ethnology) that the architecture of these and other Pueblo Indians was almost wholly, as they were themselves in part, derived from that of older cliff dwellers. But it seems that the Northerly cliff dwellers were the first in this long succession, as the Zuñis were (to the extent to which they were descended from them) their earliest successors. Yet as the ancestors of other Pueblo peoples penetrated into that constraining region, they too, under the potent influence of the same environment—probably more than by the example of these earlier predecessors who had been wrought upon thereby—adopted, one after another, a precisely similar mode of living and building. It is only eight or nine hundred years since the Navajo and Apache Indians gradually descended from their far-northern homes into this desert region. The Navajo Indians are not Pueblos, but it is sufficiently evident from facts relating to them given in the splendid treatises of Dr. Washington Matthews, that they were, especially along the line of their sociologic and religious development and the art thereto pertaining, rapidly becoming moulded, by accultural and environmental conditions combined, to the Pueblo condition of mind and life; and had their

course of development thus, not been cut short by the coming of the Spaniard with his present to them of flocks and herds that made nomads of them again, these already half-settled peoples would have become more settled and would have gone on developing precisely as older populations had there developed, the more rapidly because acquiring liberally from these older populations. Thus in the course of a similar period, or perhaps even in less time, they would no doubt have become Pueblos among the Pueblos.

Now I cannot but look upon the mound-building phase of life as, like the Pueblo-building phase, something that was influenced in a similar manner; and so, while I have no doubt that the ancient mound builders represented, as do the various modern Pueblos, several distinct *stocks* of men, still I believe that all owed their culture and their mound-building proclivities to the original common influence of seashore or key-builder life, and that each successive wave of peoples who penetrated the mound area from elsewhere, acquired the practice by the combined influences of the area to much of which it was so eminently suited, and of the peoples who had therein already become fixed in it.

In like manner as the art of the mound builders seems to have been related to that of the key builders, so certain forms found by us in the keys appeared, as heretofore intimated, to have been inherited from, or directly affiliated to, that of the farther south—of the Antilles, and even of South America. I need only refer to the labret and ear button, the latter of which, although common enough in the mounds, was still more prevalent in the keys, and was a peculiarly southern object of adornment, having prevailed universally throughout northern South America, and, indeed, throughout meridian America generally. This is true also of both forms of the atlatl found by us. They were not only South American as well as Central American in type, but on them were repeated even the decorative details of Yucatecan forms. In the pointed and spooned paddle; in the celt which, with its counterpart in stone from the Cumberland (and in little amulets from other portions of the mound area) which corresponded strictly with celts found throughout the greater and lesser Antilles; and finally, in the remarkable war club I have described in a former page, this affiliation of art-types was even more strikingly apparent. For, as I would repeat anew, this form of war club, at least, could scarcely have been other than a survival of a double, semicircular bladed hatchet that is peculiarly a South American type, as were war clubs like it—and also derived from it—in both South and in some portions of Central America.

When it is reflected that a not inconsiderable number of other forms found by us in the court of the pile dwellers were, as were those that I have so particularly referred to, almost too minutely identical with like southern forms to admit of wholly independent origin (although there is every probability that they had developed, even if elsewhere, yet in a generally similar kind of environment), and when this fact is con-

sidered in connection with the trend from south northwardly past the keys, of the main current of the Caribbean sea (as shown in Pl. XXV) and with the usual course of the great but intermittent Gulf hurricanes, it seems to me highly probable that not from the mainland, but from the sea, not from the north, but from the far south, the primitive or earliest key dwellers, whoever they were, came or were wafted in the beginning. While it is true that only a few years after the discovery by Columbus, the earliest voyagers to the Gulf of Maracaibo found peoples living there (as some few of them still live) in pile-supported houses out in the midst of the shallow waters, and hence named the country Venezuela or "Little Venice," and while it is also true that this current of the Caribbean Sea thence takes up and is thence reinforced by the current of the mighty Orinoco, still I do not believe that the derivation of these foreign arts of the key dwellers, or of the key dwellers themselves, may be traced quite so directly as that. I believe, rather, that here and there all through the waters washing the shores of lands southward from Florida—of Cuba, of Yucatan, of northern South America—we shall shortly find, unless the maps deceive me, evidence of a former very wide distribution in that direction of the key-dweller phase of life, and it has seemed to me that as the key dwellers of Florida may have borrowed from these older and more widely distributed peoples of their kind (who were probably more of South American than of North American extraction) so other peoples along that lengthy way, may also probably have derived many of their characteristics, and some small proportion of their populations perhaps. A study, for instance, of the ruined cities of Yucatan and some other portions of Central America, makes it clear that although the Mayas and other peoples who built them had advanced to a remarkable stage of barbaric civilization, and were possessed of a very highly developed architecture, yet they were at most, only highly, advantageously developed and elaborated, *mound builders*. The fact, now well known, that they entered Yucatan with arts nearly perfected and were themselves correspondingly advanced in culture when they came thither from the sea (as they claimed), seems to bear out the supposition that they owed their habits of high foundation building, their many arts almost perfected from the beginning of their occupancy, and to some extent their own origin, to a key-dwelling phase of existence.*

*I am not alone in thus having found a decided correspondence between the arts of the ancient Floridians and other Southern Indians and those of ancient Yucatan. Other observers, in particular Dr. Daniel G. Brinton, Profs. F. W. Putnam, William H. Holmes, Frederick Starr and Dr. Cyrus Thomas, have noted umistakable similarities between the arts of Yucatan and Mexico, and those of the mound builders of the Gulf States. I think it has been held that these arts traveled overland in some way along the far-reaching western and northern Gulf shores from south northward. As I have already stated, however, arts, and especially ceremonial and decorative art forms, do not readily travel from one tribe to another, are not easily adopted by one primitive people from another, unless both peoples are in a very similar grade of cultural development or share a common environment in which these arts are natural and at home. Moreover, it is to be reflected that not only arts, but also peoples (in sufficient numbers to impress their culture

The foregoing more or less speculative conclusions have been offered tentatively, not as final, but for whatever value they may possess as suggestions. After all, the collections and observations under consideration are equally interesting whether these suggestions be true or not, or only in part true. Quite aside from all this, the large proportion of objects in perishable material, recovered by us, renders our collections from the keys unique in one respect at least; serves to illustrate how very little, after all, of the art of a Stone Age people (or in this case Shell Age people) is really represented by the remains that are commonly found on the camp sites and in the burial places of such peoples. Had my collections and observations been confined to the shell, bone, horn, pottery and other specimens in comparatively enduring materials found on the keys, the art that they represent would have seemed exceedingly crude, almost below the average of Stone Age art generally, here in America. As it was, however, the carved and painted works in wood alone, in these collections, served of themselves to indicate that here were the remains of a people not only well advanced toward barbaric civilization, but of a people with a very ancient and distinctive culture, whose relations with other peoples may, through these same rare specimens of their arts—that alone by immersion in the water courts were

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or arts upon others) travel very slowly by land—impeded as they are in their course if it be long, by tribe after tribe, and danger after danger. But both arts and peoples travel with the utmost facility by sea. Therefore, it must have been, if not by slower derivation through the key dwellers, then by a wholesale sort of intercourse by sea, that these arts of the civilized peoples of Central America came to be so liberally represented among the remains—especially certain ceremonial and decorative remains—of the Indians of our Southern States, if, indeed, they came from so far south northward and were not, as I incline to think, distributed or inherited from some common centre.

In this connection I will mention also, that Prof. Holmes has found probable traces of Caribbean art in Florida. By an examination of the collections gathered by ourselves as compared with those made by Mr. Clarence Moore throughout the eastern half of the State, however, I find that these Caribbean art forms are less characteristic of our collections than of those from the easterly portion of the State, and even from the Atlantic side of southern Georgia. While the art characteristics I am speaking of, chiefly exhibited in the involuted and concentric surface decoration of paddled pottery, may be accounted for as having originated independently both among the Caribbeans and here throughout Floridian areas—from the graining of the wood of the paddles themselves, or of worn-out wooden vessels in imitation of which this pottery was no doubt at first made—still, there is a large degree of probability that the Caribs had more or less impressed their art, and even themselves, upon a portion of the native population of Florida, long before the discovery. This probability is rendered the greater by the linguistic correspondences which Dr. Albert S. Gatchet has clearly traced between the languages of the aborigines of eastern Florida, the Timuquanans, and the Caribs. However, these Carib influences seem to have come into Florida, not by a westerly way, but from the south and the east, possibly through the Lucayos or Bahamas Islands, the inhabitants of which were within historic times, as is well attested by the earliest writers, in continual intercourse with the natives of the Florida Peninsula. Such traces of Antillean art as are found in the region of the ancient key dwellers and further north on the western, or Gulf coast, seem to be rather more ancient than the date of Caribbean occupation, even of the West Indian Islands themselves, that is, they seem to be far more *Arawak* than Caribbean, and this again coincides with the idea of a very far outhern origin (in the beginning) of these peoples of the keys.

preserved to us—be studied in many ways with unusually satisfactory results.

Another feature of these collections, of equal, if not of greater interest, is the fact that they represent a Shell Age phase of human development and culture. Their art is not only an art of the sea, but it is an art of shells and teeth, an art for which the sea supplied nearly all the working parts of tools, the land only some of the materials worked upon. A study of these tools of shell and teeth furnishes us with an instructive lesson as to the ingenuity of primitive man, as to his capability of meeting needs with help of what would at first seem to be impossible, or but very indifferent, means; and as to the effect of this on derived art in general. The lesson is suggestive. It would seem to indicate that not here alone, or in those more extended regions of subtropic and tropic America which I have mentioned as possibly the homes of like key-dwelling peoples, but that in many further parts of the world—of the Old World as well as of the New World—such a phase of development may well have been passed through by whole peoples who later became stone-using peoples; yet whose earlier art of the sea had in like manner influenced the art of their later conditions, of their inland descendants and those who came into continual contact with them—just as this art seems to have influenced that of the mound builders and as a similar art—possessing no less striking marks of the sea, seems to have influenced early men in southern and eastern Asia—like the aboriginal Siamese and Cambodians, Coreans, Chinese and Japanese. Nearer parallels yet, may be found among living peoples, as before stated, those of Borneo and Papua and other parts of the Eastern Archipelago, of the Caroline Islands and other parts of Polynesia. The further question is therefore suggested—whether perhaps, in some portions of the world (man having in all probability made the very beginning of his development as a tool-maker upon the food-abounding seashore of some tropic land) whether in the phase of life here exemplified among the keys, we may not (despite its far higher development), find some intimation of the remotest of human beginnings in the use of tools and weapons as made of sea-produced and other *organic* materials. At any rate, since returning from Florida and studying such sea-land remains as I could find in various museums, and in one case studying them in the actual field (on the coast of Maine, this last summer), I have found that teeth and shells, wherever suitable kinds of these natural tools of the animals themselves could be secured, have played a far more important part, even in the arts of peoples who had abundance of excellent material for stone implements at hand, than has hitherto been realized.

There is no subject in the range of anthropological study, and this especially applies to the study of prehistoric anthropology, which can take rank above the subject of ethnographic origins. By this I mean, for the moment, neither the relations, nor the migrations of peoples, primarily, but the study of peculiar arts, institutions, and other cultural

characteristics, as influenced by given or specific physiographic areas. As affording a concrete example of this kind, of the interrelation of man and a particular kind of environment, I know of few cases in which the evidences are so direct and pronounced and I may add, unmistakable, as they are in the peculiar art remains which we discovered in this not less peculiar region of the keys.

I have presented not a few illustrations of this influence as giving rise to key building, and some phases of the life itself of the people who built the keys. Yet in closing I wish once more to recur to the subject. In a preceding note, and in former writings (published in periodicals and in the Reports of the Bureau of Ethnology, on the Zuñi Indians, and the ancient Cliff Dwellers, and the development of Pueblo culture in general), I have shown how the desert of our great southwest and the necessity for overcoming there, the difficulties of existence in an arid waste, may account for the high development towards civilization of the peoples who for a long time dwelt there. It is, indeed, safe for us to infer from these and later studies, especially those of Prof. W J McGee, that the very beginnings of true civilization, in the matter, for example, of agriculture, must ever have been made in desert environments more or less like these, more or less, also, in the same manner.

Well, so in other ways it was, in the wild region of sea, the great sea-waste wherein the ancient key dwellers reclaimed and built their homes. It was as truly a desert, not of the dry land, but of the waters, and likewise it both forced and fostered, rapid and high development of the peoples who entered it and elected or were driven to abide in it. That the island homes of these peoples, the shell keys, might be built, and in the ample water courts thereof a constant supply of fish be provided, it was even more necessary, after such beginnings as I have pictured on a former page, for men to unite in each single enterprise; the which led directly, not only to increased communality, but also to a higher, and in this case, an effective degree of organization. The arid deserts have led men like the Pueblos to continued agricultural effort wherein it was necessary for them to closely unite in the watering or irrigating of the soil; and concomitantly it has led them to a high degree of architectural development in not only granary-, and house-construction itself, but also in protective building, fortification, against those who, tempted by the ample stores thus garnered, sought to rob them; and finally, it has led, through these two causes for united effort, to high communal organization and high *sociologic* and sacerdotal government. But the men of the desert sea wastes, here among the keys, were beset by dangers far greater than those of human foemen, necessitating far more arduous communal effort in the construction of places, rather than houses, of harbors and storm defenses, rather than fortified dwellings; and the construction of these places under such difficulty and stress, led to far more highly concerted action and therefore developed necessarily not only sociologic organization nearly as high, but perforce a far higher *executive* governmental organization.

The development of the key dwellers in this direction, is attested by every key ruin—little or great—built so long ago, yet enduring the storms that have since played havoc with the mainland; is mutely yet even more eloquently attested by every great group of the shell mounds on these keys built for the chief's houses and temples; by every lengthy canal built from materials of slow and laborious accumulation from the depths of the sea. Therefore, to my mind, there can be no question that the executive, rather than the social side of government was developed among these ancient key dwellers to an almost disproportionate degree; to a degree which led not only to the establishment among them of totemic priests and headmen, as among the Pueblos, but to more than this—to the development of a favored class, and of chieftains even in civil life little short of regal in power and tenure of office.

A curious side of their life may be seen to have almost unavoidably helped toward such a development. With agricultural peoples of the desert, beginnings are almost always made normally,—in the totemic or purely clanal condition of development. Thus the lands, the garnered stores and the very houses, belong primarily to the women, and therefore the existence among them of *men* of a highly privileged class—as, of any directly hereditary line of chieftains—is rarely, if ever, fostered. On land, it was not until by the domestication of animals and the wandering pastoral mode of life this involved was adopted, that formal patriarchal or gentile organizations replaced mother right in property and the matriarchal or clanal organization of society and government—since only then did property come to be held by the *men*. For it was not until men held all-important possessions that they took the lead, and by ever-increasing competition in these, ushered in the growth of privileged classes, the establishment of *direct* heredity, and so, of lines of patriarchal elders, headmen or chieftains. But it may be seen that here on the keys the case was different from the very outset. The one most important possession of the key dwellers was the *canoe*. This was essentially a *man's* possession. Thus what on land was effected by the possession (by the men), of herds and beasts of burden, was here in the sea effected by that of an inanimate (but supposedly animate) vehicle of burden, the canoe. While the women stayed at home in the houses of the safe and isolated keys, the men continually went forth over the surrounding waters in these canoes that were owned by themselves. Being the possessors of property so important to the lives of the whole people, here where the plan of social organization was still, no doubt, at least traditionally totemic, it must nevertheless have become to a limited extent patriarchal—virtually so, as far as the ruling class of men was concerned. This property-right of the men, in canoes that were so directly related to the public works which fostered the executive function in government, then, helped, I take it, toward the establishment of king-like chieftainships; and the main point of this seeming digression is, that it was due to this kind of life and development originally, and to

inheritance therefrom, that all the great southern tribes encountered by De Soto and his successors, were ruled over by the most powerful chiefs we know of, outside of Mexico, Peru and Central America, anywhere on this continent; namely, the Mikos or King-chiefs, who had actual power of life and death over nearly all—save members of the priesthood—among their subjects, and were held to be of divine descent.

This abnormally high development in government, indicated by great public works on the keys and among the mounds, and in a measure by historic records, is, as we have seen, paralleled in the arts of the keys, for in them we found, along with an exceedingly high growth of the conventional side of art, an artistic freedom on the æsthetic side that I have not seen equaled in any of the primitive remains of this continent, elsewhere, save alone perhaps, in those of Central America. This gives good ground for another generalization; that while the desert of the land, with its scant vegetation and scanter animal life, leads naturally, yet through the technique involved, to *formal* conventional art, the desert of the sea, teeming with growth and quick with animal life in untold variety, beauty and abundance, leads as in this case, and for like reasons, not to formal, but to highly realistic conventionalization. In the one art, that of the land desert, may be found abundant textile and basketry forms of decoration. There, life seems to have been held so dearly that only in angular or geometric style, or by means of pure symbols rather than by direct representation, were animistic qualities *attributed* to things made; so that above any other art, the art of the arid desert may be called *attributive* art. But here in the sea wastes, where life so abounded, the *forms*, alike of animals and of men, were lavishly, most realistically and gracefully represented, and the commonest tools were shaped over with quite unmistakable life-marks and other added features, and were thus, while conventionally, withal realistically and fearlessly *invested*, with their animistic and specialistic powers. So, in contrast to the art of the inland desert, this of the sea may be called an *art of investure*. It seems to me that now possessing as we do examples of these opposite extremes of art (for museums are filled with the one extreme) there is scarcely a primitive kind of art, ancient or modern, which cannot be measurably interpreted by comparative study of the one kind (the conventional and attributive) and the other kind so clearly illustrated by our collection (the realistic and the conventionally investive). In this, then, as in its exemplification of man's direct relationship in cultural and even perhaps in racial development, to his environment, our study of the ancient key remains, takes its place in the general study of the Science of Man.

I have only to add that the combined archæological data and collections which we gathered from the ancient keys, were together so complete (happily because so many perishable objects were preserved intact and in their proper relations) that they might be called, what though so very ancient, almost literally ethnological, rather than archæological

collections. The specimens themselves are now sadly warped and shriveled. But happily some of them can be fairly restored by treatment with preservatives ; and happily also, our photographs, drawings and paintings, and casts, made in the field, are almost equal for study to what the originals were when found. Thus, after the original series is arranged and exhibited here in the Museum of the University of Pennsylvania, and after a duplicate but representative series is displayed in the National Museum at Washington, further comparative study of them will be possible, and through this study the ancient key dwellers as a people, the story even of their modes of daily life, will become known to us so fully as to make it almost like unto one which might be told of a living people. And were it possible now, I would fain present a picture of this olden life on our shores—so remotely pre-Columbian and so truly primitive—since I am sure that with the materials at hand it could even now be made more perfect and detailed than any relating to a period equally remote, that has thus far been possible. Certainly it could be so made when aided, not only by comparative study of the works of such peoples as, let us say the Arawaks of Brazil and the Orinoco, but also, of the early historic records. Still, I shall have to content myself—and perhaps it is just as well, since this will give time for carrying the details of such study much further—with presenting a picture of the kind in the final, fully and amply illustrated volume of the Pepper-Hearst Expedition, which Major Powell has so liberly consented—as a joint work of the Bureau of American Ethnology of the Smithsonian Institution, and the Department of Archæology and Palæontology of the University of Pennsylvania—to publish.

DESCRIPTIVE LIST OF PLATES XXV-XXXV.

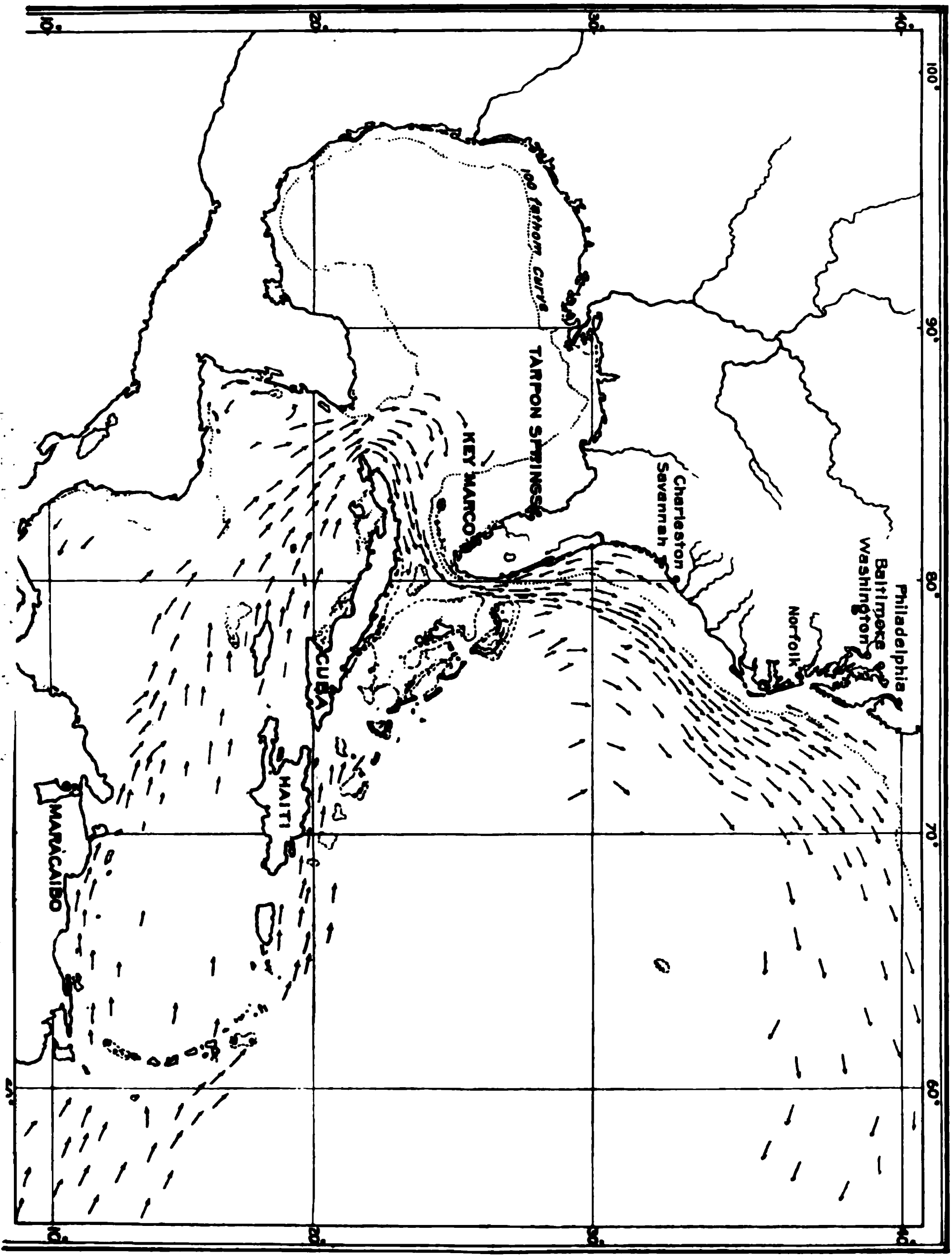
WITH EXPLANATIONS OF FIGURES, AND TEXT REFERENCES.

PLATE XXV.

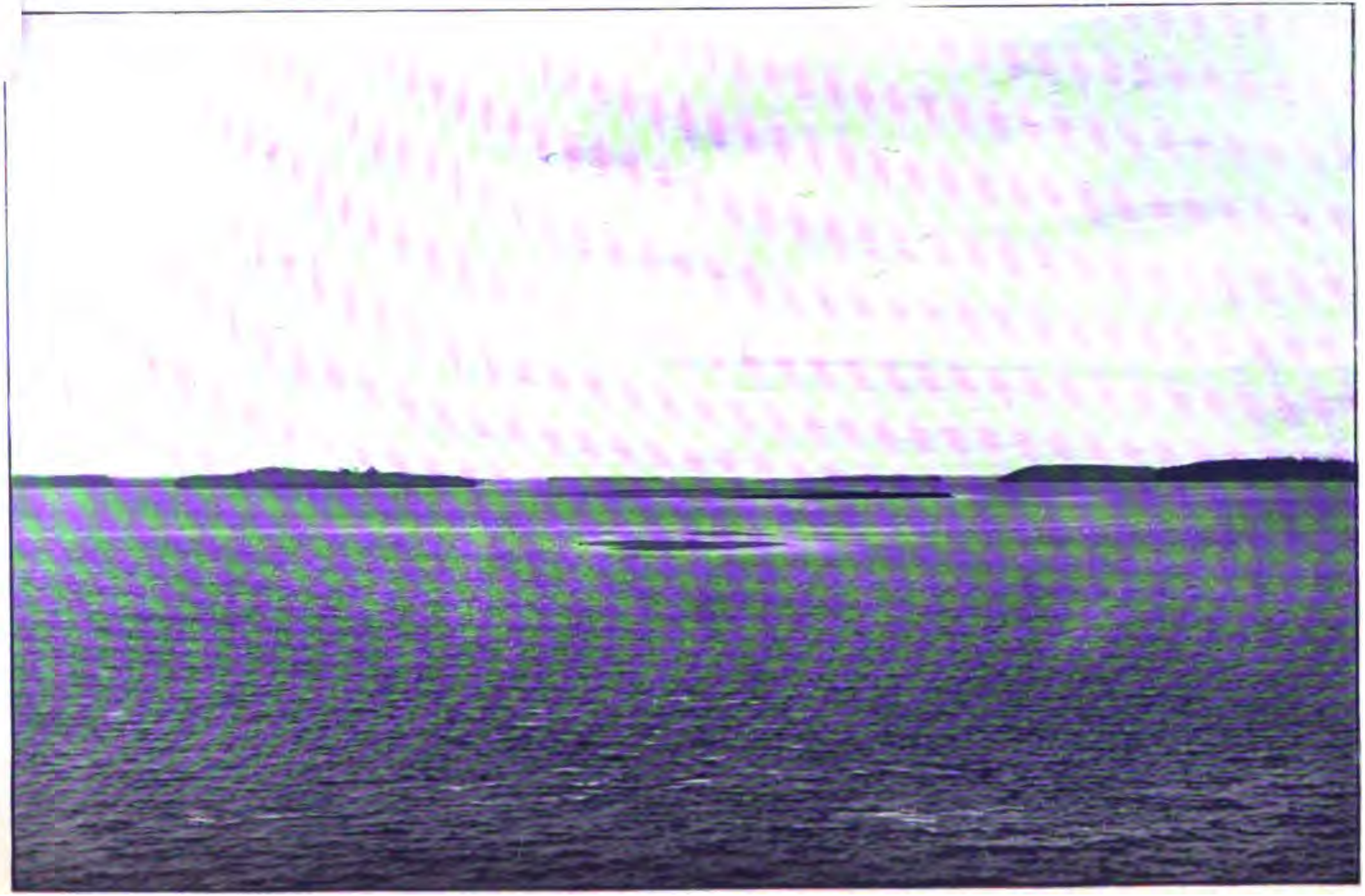
The outline map, shown on Plate XXV, is reproduced from the latest Government Hydrographic Surveys, and indicates the location of Tarpon Springs,—the northernmost point on the Gulf coast of Florida (see pp. 351 to 354, inclusive), explored by the Pepper-Hearst expedition of 1896; also the location of Key Marco and of the contiguous archipelago of the Ten Thousand Islands,—which probably contains not fewer than fifteen hundred ancient key-dweller settlements or artificial shell islets.

It is designed especially to illustrate the relation (discussed on pp. 408, 409 and 410 in the text) of the Currents of the Caribbean Sea to the principal island clusters or settlements of the ancient key-builders, as probably bearing, to some extent on their remote origin. The series of arrows represented as leading past the gulf of Maracaibo, in South America, thence through the strait between Yucatan and western Cuba, and thence in turn, to the keys and islands of southwestern Florida, defines the current, which is regarded as having been influential in peopling these areas of the keys with wanderers—probably of Arawak extraction, *via* the region of the Orinoco in South America.

Again, the series of arrows represented as passing northwardly along the outer or Atlantic side of both the Lesser and Greater Antilles, and thence to the Lucayo or Bahama Islands, defines the current which is regarded as the possible line of comparatively recent Caribbean derivation, as evidenced by various art remains in eastern Florida and Georgia, which are referred to, in the footnote on page 410, as discovered by Prof. Wm. H. Holmes.



Location of Ancient Shell Settlements of Key Marco and the Ten Thousand Islands on the Gulf Coast of Florida, in relation to Currents of the Caribbean Sea.



Keys and Reefs among the Ten Thousand Islands, near Marco.

PLATE XXVI.

The view presented on Plate XXVI illustrates the appearance of certain shoals and islets to the eastward of Key Marco, in the northwesterly edge of the Ten Thousand Islands. It admirably exhibits the form of an original oyster-bar or coral-reef, as defined by the lines of foam caused by the rapidly retreating tide. It will be observed that these lines enclose a central space of deep water (between the two black masses of reef-crags already exposed), and that these foam lines extend off laterally, forming an irregular, atoll-like, or semicircular enclosure, that greatly resembles the outline or plàn of a true, built up or artificial key, or shell settlement.

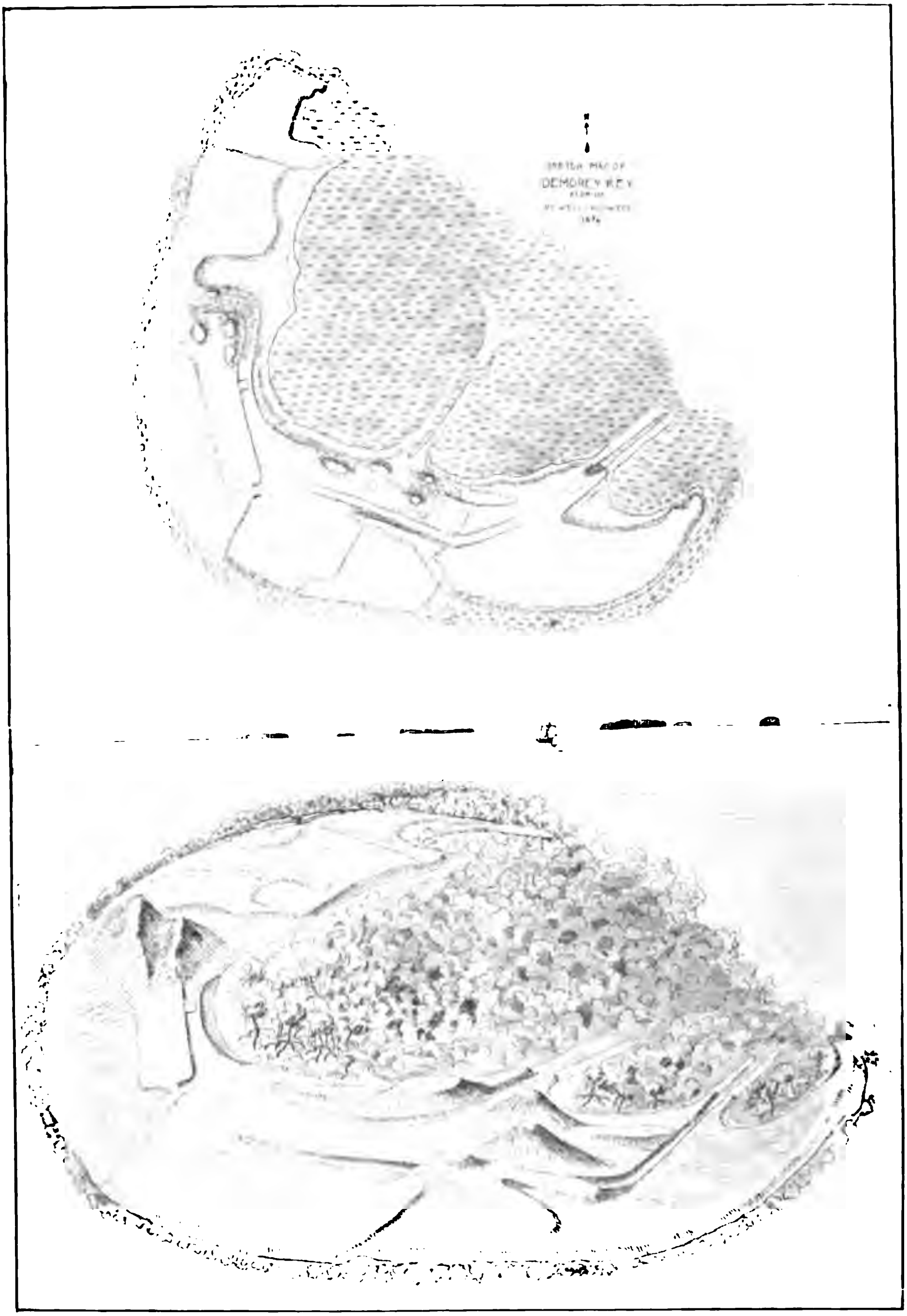
For this and other reasons—discussed at length on pp. 335 to 337, inclusive, and incidentally elsewhere in the text—it is supposed that the earliest key-builders made the beginnings of their great shell structures or islands (such as are mapped on Plates XXVIII and XXX) upon reefs and shoals like these.

The appearance, seen from a distance, of these shell islets or keys, when overgrown and surrounded by mangroves, as nearly all of them are, is quite well shown toward the left, and also at the extreme right, of the picture.

PLATE XXVII.

The photograph reproduced on Plate XXVII, was taken from the southern sea-wall of Cayo del Oso, or Bear Key (visible in the leftward distance of the view on the preceding Plate,—XXVI). The outlying portions of this key had been burned over, on the hither side, and although the inner portions were not typically lofty or extensive, nevertheless the marginal structures of the keys in general,—as described on pp. 331 to 350, inclusive—were here exceptionally well revealed. Hence, this view was chosen from among many more impressive scenes, as best illustrating the surrounding enclosures and other details of such keys: First, of the sea-walls, outwardly fringed by mangroves (both seen to the left of the picture); of a small fish-pound or water-court with its little outlet-canal seen beyond the second ridge of the foreground); and of a larger, partly filled water-court (seen between the third ridge and the western sea-wall —its canal leading off among the trees and bushes to the right). Unfortunately the heights of this key are hidden, or are at best but slightly indicated—in the shrubbery at the extreme right background of the view—giving an impression of flatness that is not characteristic.

Sea-walls and Enclosures surrounding Ancient Shell Settlement at Bear's Point or Cayo Del Oso, of the Ten Thousand Islands;



Plan and Elevation of Ancient Shell Island or Settlement of Demorey's Key, in Pine Island Sound.

Plate XXVIII.

In the plan and elevation of Demorey's key presented on Plate XXVIII (described at length on pp. 338 to 341, inclusive), one of the most perfectly preserved, and probably most recent, of the ancient shell settlements or artificial islands of Charlotte Harbor.and neighboring waters is outlined.

The upper sketch-map, although not sufficiently detailed, was drawn from a careful survey laboriously made by myself, and gives a fairly accurate general idea of the terminal terraces, the two inner canals, the principal graded way, the central group of mounds and pyramids, and the great crowning terrace—with its subsidiary platform of approach—as in part illustrated in the succeeding Plate,—XXIX. Unfortunately, however, neither the sea-wall extensions, the nearly submerged enclosures within the swamps, nor the drainage- and garden-basins—or "Spring holes," locally so-called—in the northern benches or low platforms, could be properly shown on this scale.

The subjoined elevation was redrawn from an imperfect sketch of my own taken from the top of a tree, necessarily inside the key, and hence it gives a view-point that does not quite coincide with the more correct orientation of the map above. Nor does it correspond in scale—of details,—hence the central group of mounds appears too far to the right, and the altar-mounds at the end of the crowning terrace are unduly exaggerated in both height and length. Nevertheless, the general contour of the elevations here shown will serve to suggest, in a measure, their striking similarity to mound-groups in the Mississippi and tributary Valleys, and to the terrace-, or platform-builded foundation-structures of ancient Central American cities, referred to in the concluding paragraphs of the text, on pp. 108, 109.

PLATE XXIX.

The view of the rounded corner and a portion of the side at the south-eastern end of the shell-faced platform on the crowning terrace or elongated pyramid-mound of Demorey's Key, Pine Island Sound, given in Plate XXIX, does not, unfortunately, include the subsidiary platform of approach at the farther end. As related on pp. 338 and 339, the vegetation covering this and nearly all other portions of the key, was so rank, that but for an accident, the character of the shell work of this terrace would not have been even suspected. Hence too, the tessellated pavement of clamshells along the lines of approach to the side platform and toward the end of the main work, were exposed only here and there, at great labor, and therefore do not appear in the picture. It will be observed however, that the apices of many of the shells in the facing of the terrace, are crushed in. It was found that as this ancient façade was built up, the conches were laid in place—the whorls of each course all turned one way—and that finally all were hammered into place more firmly, until the whole facing was thereby made even. It was thus that the points or spires of some of the shells were broken in as shown. I later learned that this mode of building was resorted to not only in such facings of the heights, but also in the laying of the foundations of the keys on the submerged reefs.

Crowning Terrace of the Great Mound or Pyramid on Demorey's Key, showing Platform and Conch-shell Facing.

Topographic Map of Key Marco, showing Sea-wall, Water-courts, Canals, Cenotes or Round Reservoirs, Garden-terraces and Central Mounds.

Plate XXX.

The contour lines in the Topographic map of Key Marco (represented on Plate XXX, and described on pp. 349, 350, of the text), by means of which Mr. Sawyer has indicated, with the utmost fidelity and accuracy, the minutest features of that remarkable and gigantic structure, necessarily have to be reproduced here in one color. Therefore, the significant difference between elevations and depressions above and below the mean or high tide level are not clearly apparent. For example, the circles and parallel lines in the extreme southeastern portion of the map, represent deep round wells or basins, and almost equally deep canals and graded ways leading to and from them; while the quite similar, although more numerous, lines at 13′, 14′ and 18′, in the easterly central portion of the map, indicate mounds and other heights above the mean, corresponding, in foot-measure, to these several figures.

The long, narrow water-court or fish-pound—at the northern end—still slightly open to the sea through its short canal; the three larger courts—respectively twenty, thirty, and fifty feet wide—down on the western side, and the larger triangular "Court of the Pile Dwellers" excavated by us and shown more fully in the plan on Plate XXXI, are all indicated by flat shading, and are marked with mangrove signs.

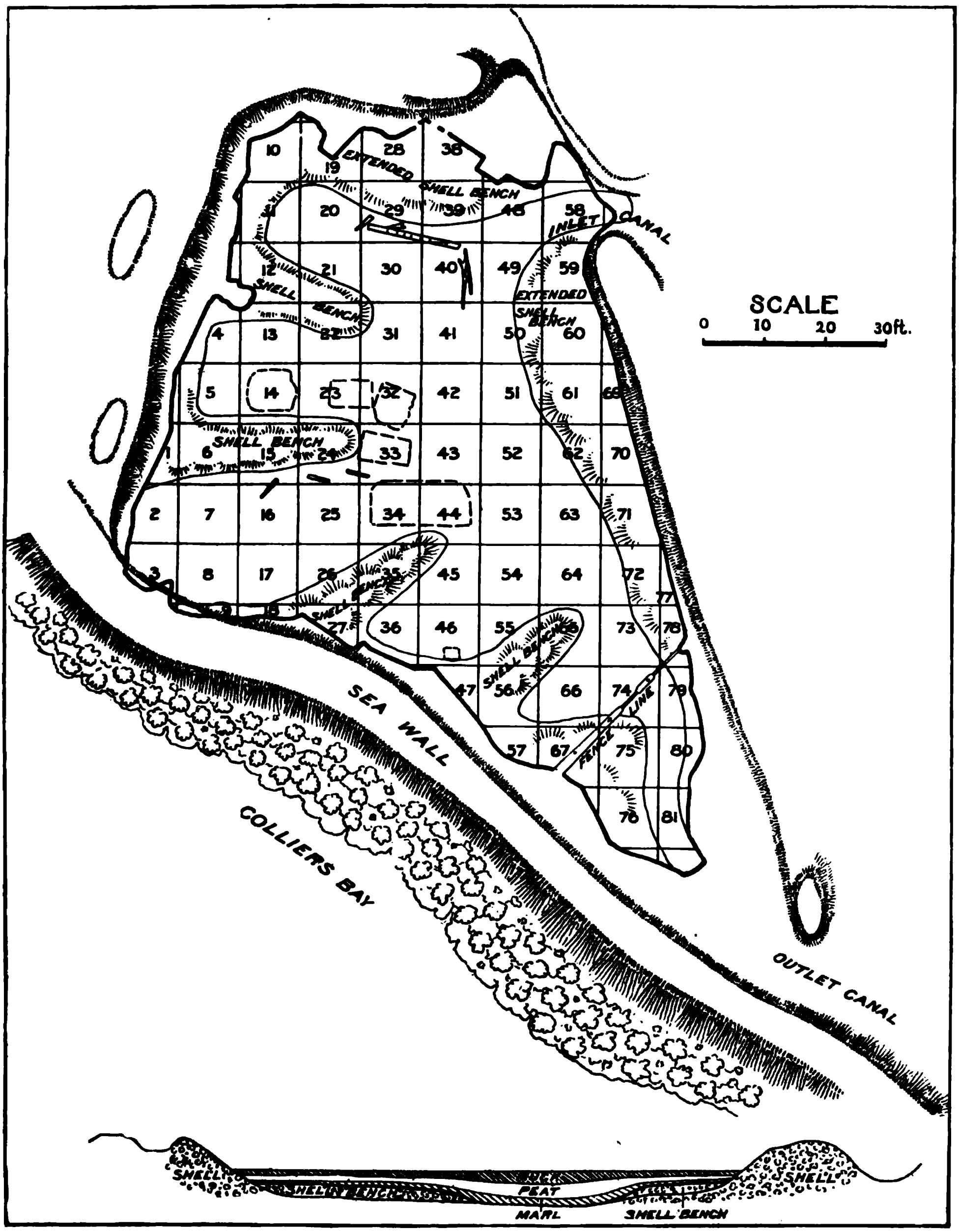
It will be noted that above and toward the left of this court, are two similar courts, that had been filled nearly up to their marginal rims, probably to form gardens or platforms; and that to the right, the very large bayou at the southern end of the key was already being reclaimed for the formation of additional courts or enclosures, by the extension of the shell works down toward the terminal eastern sea wall. Excavations revealed the fact that in places the borders of this bayou were already occupied by dwellings like those of the courts, at the time of the abandonment of the place.

The eastern edge of the key was worn away by the sea. The termini of canals similar to those on the northwestern edge, as well as the general oval outline of other portions of the key, indicated that it originally extended a little more than two hundred feet out in this direction, and that it probably here also contained water-courts, fish-pounds and other features, like those lower down on the opposite margin. It also indicated that at the time of abandonment, the place of the extensive mangrove swamp to the southward, was open water, and that the main tidal current between the key and Caximbas island further to the south, flowed past this easterly portion. It is remarkable that Key Marco is exceptional in having thus been somewhat demolished; for of more than a hundred keys examined by me, first and last, only this and five others had been disturbed by the countless storms that have, throughout unnumbered centuries, swept those regions and changed, on every hand, all other sections of the coast. During the ages that must have elapsed since these gigantic structures were piled up, they have stood unscathed, the stress of tidal wave, and flood and storm; and they were, in early historic days, as is abundantly attested by old writers, used as places of refuge in times of inundation, by Indians, as, indeed, they have continued to be used ever since, even by modern settlers.

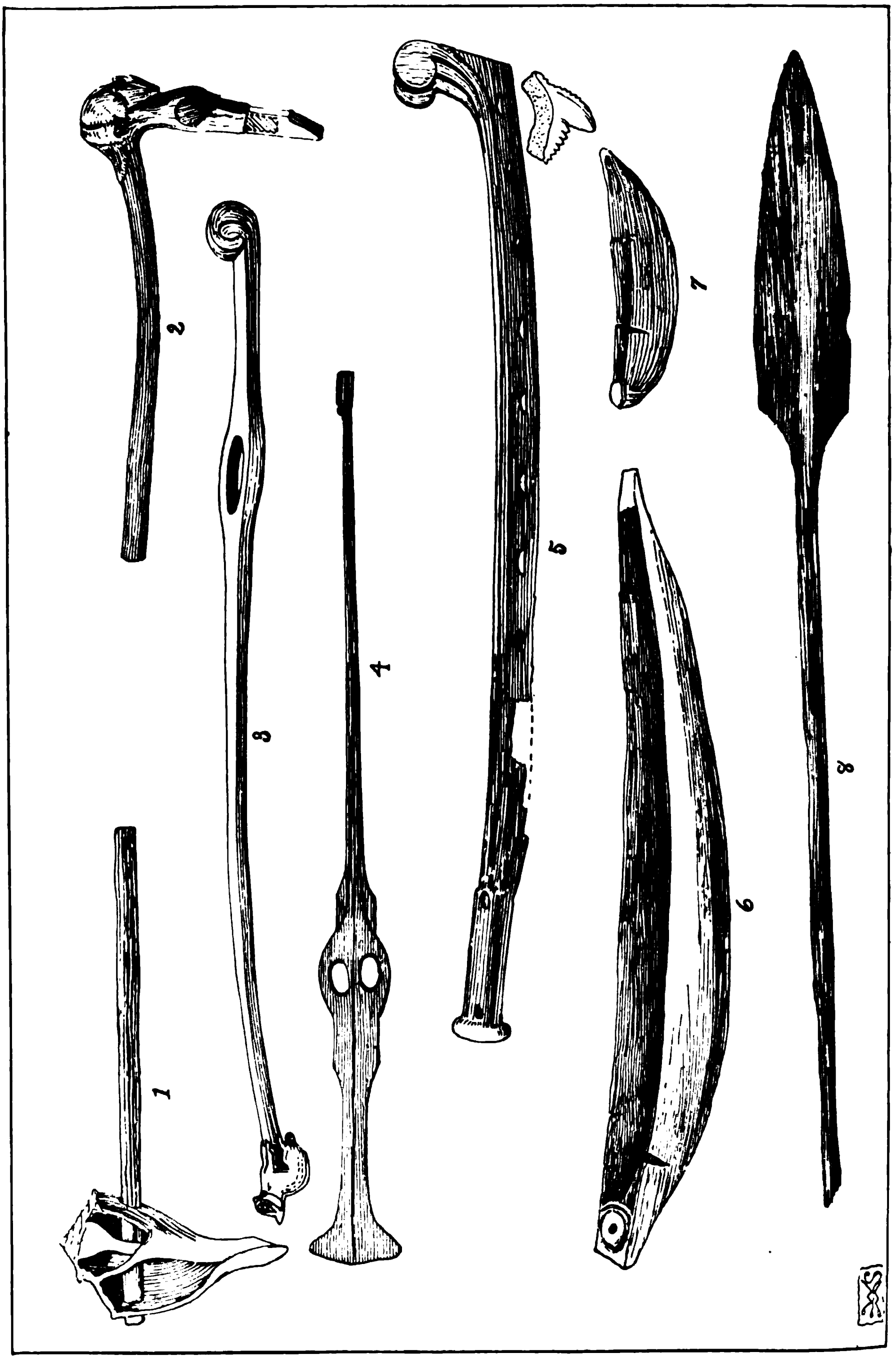
Plate XXXI.

Little more need be said of the Plan and Section of the "Court of the Pile Dwellers" at Key Marco, shown on Plate XXXI, than has already been remarked in the text (on pp. 350, 356, and succeeding pages, and again in the explanations of figures, that follow).

The section below this plan corresponds to an east and west line through the court from above section 1, to above section 70; and the heavy black border-line around the margins of the court, represents accu rately the area cleanly excavated by us. The locations of preliminary excavations by Collier, Wilkins, Durnford and myself, in sections 14, 28, 32, 33, 34 and 44; those of the shell house-piers and -benches, and those of structural finds and of the inlet- and outlet-canals, are significantly indicated by the dotted enclosures, legends, and graphic figures.



Plan and Section of the " Court of the Pile Dwellers," at Key Marco, showing Locations of Excavations and Finds.



Types of Implements and Weapons; Toy Canoes and Paddle.

Plate XXXII.

Only a few typical examples of more than two hundred fairly well preserved tools and weapons recovered by us from the court of the Pile Dwellers, could here be figured.

Fig. 1. Represents a hafted busycon-, or conch-shell gouge or adze—such as described on p. 368. The length of the handle, which was of buttonwood, was fifteen inches; of the shell head or armature, seven inches. This particular specimen was found by Gause, close to the edge of the shell bench,—in section 21 (Plate XXXI).

Fig. 2. Represents the handle of a carving-adze of hard, dark wood, like madeira in appearance. It and others of its kind are described on p. 369 of the text. The length of its handle, from end to crook, was twelve inches; of the head, from the crook down to the insertion of the socketed blade-receptacle of deer horn, five and a fraction inches; and of this ingenious bit-holder, three inches. It was found with eight other similarly crooked and socketed adze-handles—all contained in a ceremonial pack,—in section 40 (Plate XXXI).

Fig. 3. Represents a superb, single-hole atlatl, described with others, on pp. 371 and 372. It is, by an oversight, figured upside down in this illustration—the tail of the rabbit-carving at the end, having been skilfully adapted to form the propelling spur of this remarkable throwing-apparatus. Its length was nineteen inches, and it was made from fine, springy hard wood—like rose wood in appearance—probably the heart portion of the so-called iron-wood of the region. It was found, associated with the plugged and hollowed or "footed" shaftment of an elaborate cane throwing-spear,—in section 62 (Plate XXXI).

Fig. 4. Represents a double-holed atlatl or spear-thrower. It is described, with the preceding specimen, on pp. 371, 372 of the text, and like it, consisted of dark, red-brown, flexible wood. It was sixteen inches in length, and was found,—in section 29 (Plate XXXI).

Fig. 5. Represents roughly, one of the singular and highly finished hard-wood sabre-clubs armed with shark teeth, which are described on pp. 372, 373 of the text. They were from twenty-four to thirty inches in length, and probably, like the war-clubs of the Zuñi Indians, corresponded to the length of arm, or of thigh from hip to knee, of those who made and used them. The specimen here figured was found by Mr. Bergmann,—in section 11 (Plate XXXI).

Fig. 6. Represents a toy canoe, of cypress wood, nineteen and three-quarter inches in length. As described on p. 365 of the text, it was found with another of like proportions—to which it had been attached, probably in imitation of sea-going catamaran-canoes of the ancient key dwellers, by means of cross-stays,— by Gause and Clark,—in section 26 (Plate XXXI).

Fig. 7. Represents a little flat-bottomed toy canoe, (such as described on p. 364) of the kind supposed to have been used in canals, bayous, and other shoal waters. It was found by myself,—in section 7 (Plate XXXI).

Fig. 8. Represents a paddle of hard wood, the end of handle burned off as described on pp. 361, 366. It was found by Gause, sticking slantingly up through the muck, in the mouth of the inlet-canal,—in section 48 (Plate XXXI).

Plate XXXIII.

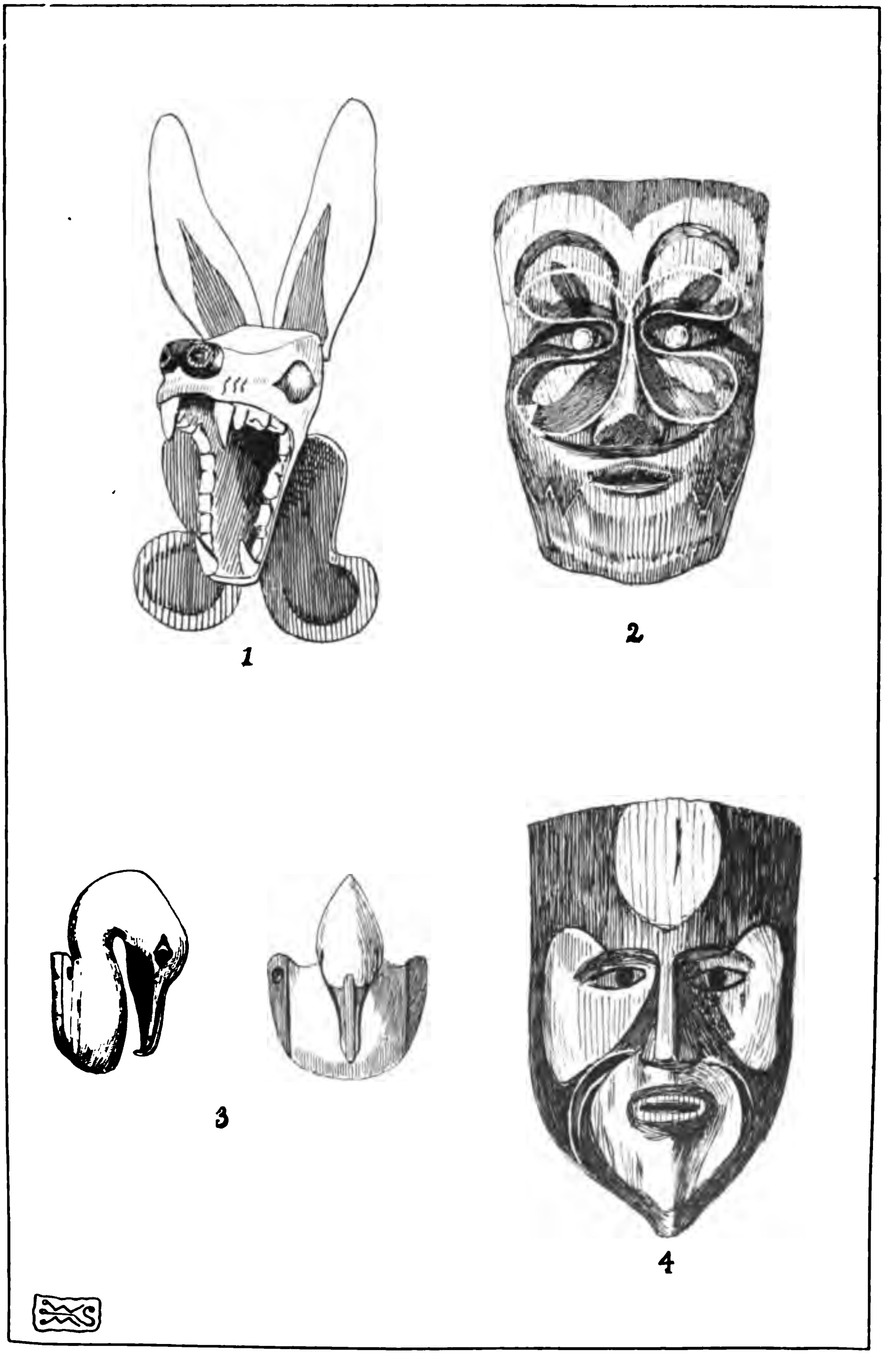
Of the many animal figureheads, and actually, as well as decoratively, associated human masks discovered in the Court of the Pile Dwellers, those of the wolf and wolf-man, and of the pelican and pelican-man only, were chosen for illustration here, not because they were the most striking or perfect examples of the kind recovered, but because they illustrate more completely than others, the singular relations and meanings of these peculiar objects of art—as I have endeavored to explain them in the text, on pp. 388 to 394, inclusive.

Fig. 1. Represents very perfectly, the wolf figurehead, as it appears when the parts are put together as the relations of the perforations and cord fragments therein indicate they were originally joined. When this figurehead was found,—by Gause and myself, in section 30, Plate XXXI—the ear-pieces were back to back, and were thrust through the hollow head-piece and open mouth; and the conventional, scroll-like shoulder and leg-pieces, were laid together in like manner, and were neatly bound, with strips of palmetto, or flag-leaf—still green in color—to the side of the head. This head-piece was six and one-half inches in length; the spread of the jaws, five and seven-eighth inches; the ear-pieces, six inches in length, and the leg and shoulder-pieces, four and six-eighths inches long. Happily, Mr. Sawyer was able to make an excellent water-color sketch of the specimen before it was disturbed, and another after it was put together and was still bright with the moisture of its centuries of immersion and preservation.

Fig. 2. Represents the human featured mask associated with this wolf figure-head. It is less perfectly shown in the sketch, since the details of its paint decoration do not, in mere black and white, show as plainly as could be desired, and hence the really unmistakable correspondence between these color-designs (in black, brown, gray-blue and white), and the general aspect and face-markings of the animal-head, is not so pronounced as in the original. But the black ear-marks over the eyes, the black, indented stripe under and around the nostrils, the scroll-like outlines of the shoulder-pieces (in white lines over all the other markings in the middle of the face), and the zigzag lines representative of the gnashing teeth or tusked jaws of the wolf (across the cheeks toward the mouth of the mask), will at once, however, be recognized.

This mask was nine inches in length, by six inches in width, and was found in the same section, (30), not only with the wolf figurehead, but also near other masks and figureheads.

Fig. 3. Represents, on a greatly reduced scale, the pelican figurehead,—found by Gause and Hudson, in section 40. This extraordinarily grace-



Animal Figure-heads with correspondingly Painted Human Masks.

ful, and realistically painted carving, was four and one-half inches high, by three inches in width of shoulders ; it was much under natural size of the bird it represented, but it was surprisingly life-like, what though so beautifully and conventionally idealized as a figure of the head and front of the pelican. Near it were thin slats, admirably cut and painted to represent the wings of the bird ; and they were pierced, as were the incut shoulders of the figurehead itself, for attachment thereto. The mask (fig. 4) found near this figurehead and the other painted carvings mentioned, was nine and one-eighth inches high, and five and one-quarter inches broad. It was unquestionably designed to represent the human, or man-god counterpart of this bird ; for not only was the chin protruded and the under lip pouted to symbolize the pouch of the pelican, but also, the rear and tail of the body (painted in white on the chin), the trailing legs (in gray-blue and white lines, descending from the nostrils around the corners of the mouth), the wings and shoulders, (in dappled white over the cheeks), and the huge bald head (in white on the forehead of the mask), were all most distinctly suggested. Moreover, on the upper edge of the mask (at the terminal point of the bird head painted on the forehead), were perforations, indicating that either an actual beak, or an appendage representative thereof, had been attached. With this in mind, if the mask be reversed and a comparison of the design on it be made with the figurehead, or with the imagined form of a flying pelican seen from above, the almost ludicrous resemblance of the design to its supposed original will readily enough be seen.

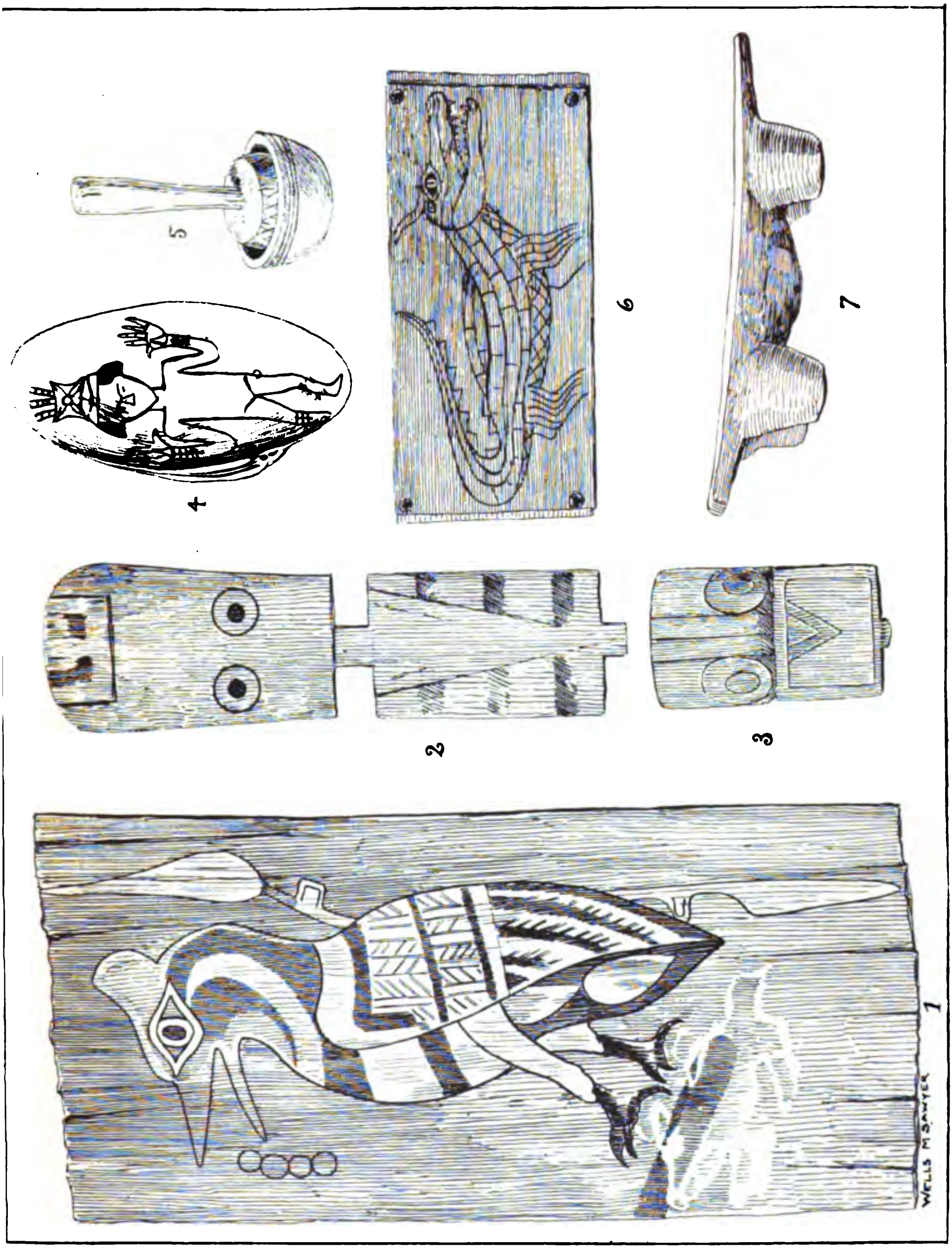
Plate XXXIV.

Fig. 1, in Plate XXXIV, represents a tablet of rivean cypress wood, shaved with shark-tooth blades to a uniform thickness of less than half an inch,—the characteristic marks of this work being visible all over the unpainted portions of both sides of the board. It was found by myself, standing slantingly upright—in section 21 (Plate XXXI), the painted side fortunately protected by its oblique position. It was marvelously fresh when first uncovered,—the wood, of a bright yellowish-brown color, and the painting vivid and clear. It is sixteen and a half inches in length by eight and a half inches in width, and was slightly concavo-convex from side to side. Upon the hollow side is painted the figure of a crested bird, with four circlets falling from his mouth. A black bar, and over it the outlines, in white, of an animal, is represented as under the talons; and a long, double-pointed object,—probably a double-bladed paddle,—as borne aloft under the right wing of the figure.

The drawing here shown was made from a very obscure photographic print, and does not, therefore, adequately show some of the minutest, yet most significant details visible in either the original or in the fine full sized painting made by Mr. Sawyer when the specimen was freshly taken up from the muck. In the first place, the bands and spaces of white on the figure, enclosed very significant zones of clear light blue, —on the crest, neck, body and wings. They do not show here, but they made it possible to identify this primitive bird painting as that of the *jay*, or else of the *king fisher*, or more probably still, of a crested mythic bird or bird-god combining attributes of both.*

* In reference to certain scarred or crest-marked skulls found by us in the burial mound at Tarpon Springs, I wrote the Chief Ethnologist of the Bureau of American Ethnology, Prof. W J McGee, as follows:

"—— ——, it is a well-known fact that certain classes of men among the Southern tribes,—notably those of the Maskokian confederacy, the Creeks especially,—wore the hair in erect crests, cropped and narrow in front, broadening rearwardly to the back of the head, where it was allowed to grow to the normal length, and whence it depended in each case, either naturally like a tail, or bound about with fur or stuffs, to form the so-called scalp-lock. The researches of Gatschet make it evident that this was the special hair-dress of the Warrior-class (see portrait of Tomochichi, a Yamasee war-chief, in Urlsperger, vol. i). He finds that in the Creek language, Tás-sa (Hichiti Tás-si), signifies alike 'jay or king-fisher' ('crested bird') and 'hair-crest;' while Tás-si ka-ya signifies 'Warrior; (lit., 'crest standing up'—that is, 'he of the erectile crest'). From other sources it appears that as the jay was regarded as more powerful in resisting even birds of prey than were any other birds of his kind,—as was also the king-fisher, so nearly resembling him, more powerful than other birds of his kind,—because of their shrill and startling cries and their habits of erecting their hair-like crests when alarmed in defending, or wrathful in offending their kind. Wherefore, the crest of the jay and of the male king-



Types of Sacred Painted Tablets and Shell, and of Utensils.

In the second place, all of the main outlines of this primitive painting, —the crest, neck, breast, shoulder, and oblique end of the tail, were delicately spaced, so as to produce the effect of double outlining and so as to enhance both the beauty and the perspective of the figure. The centres of the circlets falling from the open beak were filled with pigment—originally blue, white, and probably red,—and a tongue-like line of white extended from the mouth to the circlets and was oppositely continued in black, into the *throat* of the figure—enabling me to identify it as the heart-line, and these circlets as "living," or "sounding" breaths or words—symbolizing the "commands of the four quarters." The animal represented under the talons of the bird figure, had a long and faintly *ringed* tail, which extended nearly to the lower paddle-blade, and enabled me to identify it, in turn, as a picture of the raccoon—all as more fully described on pp. 384 and 385 of the text.

Fig. 2 represents one of those mysterious objects described on pp. 382 to 385 inclusive, as "altar-", or "ancestral-tablets." It was painted on both sides,—in black and white on the side here shown, and with four round marks of white enclosed and dotted in black, centrally and equidistantly disposed along the other side. It was made of light wood, —pine or cypress,—was two feet three and a half inches high, ten inches wide, flat, and an inch thick below the shoulders, and nearly three inches thick in the middle of convex shovel-shaped head or nose. It seems to be the highly conventionalized representation, as does the little amulet of coral lime-stone below (Fig. 3, which is barely two inches long, by one and a quarter inches wide), of some kind of monster of the deep—like the alligator, or cayman or American crocodile.

Fig. 4 represents the painted valve of a pair of sun-shells described on pp. 386 and 387; and compared as to details on pp. 393, 394 and 402, as well as in Plate XXXV, with corresponding mound builder delineations. They were found tightly closed together, and near some symbolic head-slats, on which a bird-god (like the one just described) had been painted, —in section 30 (Plate XXXI), by Messrs. Gause and Bergmann.

Fig. 6 represents a beautiful little pestle and bowl of mastich-wood found together as here shown, although tilted over—in section 40—by Alfred Hudson. The pestle was six and a half inches high; the bowl, three and a quarter inches in diameter. Both were handsomely polished and were reticularly decorated with incised lines, so delicate as to almost escape detection.

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fisher,—who were probably bird-gods of war,—came to be imitated (reproduced, so far as possible) in the head-dress (or aspect) of the Warrior—the Wrathful Defender of his People and their Homes."

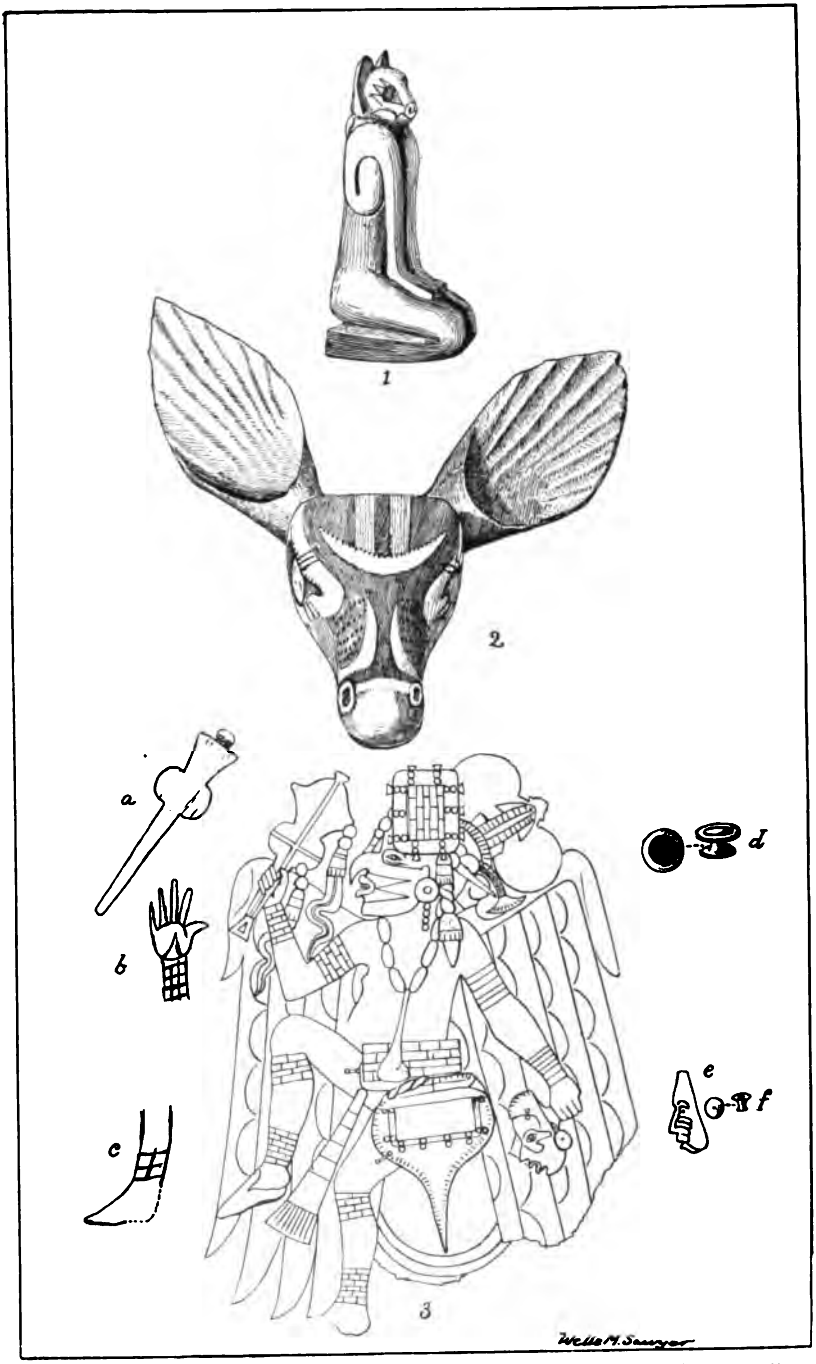
I quote this passage, which was later substantially published in the *American Anthropologist* (vol. x, pp. 17 and 18), because I think it throws light on the meaning of the tablet here described and figured, not only as being really a painting of the Bird-God of War of the ancient key dwellers, but also, because of its apparent bearing on probable historic or derivative connections of the Southern Indians with a key dweller people or ancestry.

Fig. 6 represents a little jewel-box lid or bottom, of hard, dark brown wood, eight inches in length, by four in width. The ends were rabbetted and drilled for attachment (with sinew and black gum, traces of which remained), to the ends of the box, and the ends themselves were in juxtaposition. Each end was four inches long and of corresponding width, and painted lengthwise on the outside, with double mythic tie-cords and shell-clasp figures. The bottom and the other parts were missing, save for fragments. With these fragments, however, were some of the most superb ear jewels and plugs, shell beads and pearls, among all our findings. Curiously enough, the remarkable outline of a horned crocodile, painted on this little lid as here shown, occured on the *inside*, and this plainly indicates the sacred nature of the box and its contents. It is of interest to note that the horned crocodile (or alligator) was seen by William Bartram, painted on the façades of the great sacred houses of the Creek Indians, when he visited their chief towns more than a hundred years ago.

This specimen was found by Hudson and myself, with the ceremonial pack and painted shell described on pp. 385, 386,—in section 40 (Plate XXXI).

Fig. 7 represents a stool—described, with others of its kind, on p. 363. It is seventeen inches in length, between six and seven inches in width, and at one end, five, at the other end, six inches high. It was blocked out with shell adzes—as shown by traces of hacking still visible on its under side, then finished with shark tooth knives,—from a piece of hard, yellowish wood, probably buttonwood. It was found by Clark,—in section 31.

I would call attention to the fact that it is sloped, or higher at one end than at the other. This indicates that it was designed for use *astride*, so to say, as is also indicated in other, even unsloped specimens, by the slant of the pegs or feet, which adapted some of these stools for use in canoes, lengthwise, but not crosswise. It is well known that the Antilleans, whose stools, while far more elaborate than those we found, were not unlike them in style, had a fashion of sitting astride or lengthwise of them. While this may, with many other points, signify connection, it far more certainly signifies that this curious way of sitting was established by the use of long stools in narrow canoes, and possibly also, by use of the sitting-hammock.



Statuette of the Lion or Panther-God; Figure-head of Deer; comparison of Key Dweller Types of Ceremonial Paraphernalia, etc., with Delineations on Ancient Copper Plate from the Etowah Mound of Georgia.

Plate XXXV.

The first figure here given, represents the statuette of a panther or mountain lion-god. It is six inches in height by two and a half inches in length of base, from heel to knee-bend. It is carved from an exceedingly hard knot, or gnarled block of fine, dark-brown wood, and had either been saturated with some kind of varnish, or more probably had been frequently anointed with the fat of slain animals or victims. To this, doubtless, its remarkable preservation is due ; for it is still relatively heavier, harder, and less shrunken by drying, than any other specimen of like material in the collection.

This extraordinary object of art is generally described on p. 387, and is referred to elsewhere in the text ; but I would again call attention to the fact that while the head and body are not only delicately fashioned and finished, even to the extent of polishing, the legs and the ends of the paws, although smoothed outside, are simply shaped, and,—as though purposely—left unfinished ; and the spaces below the tail—which is conventionally laid along the back after the manner of Zuñi carvings of the same sort of animal-god—and the spaces between the legs, still show the characteristic marks of the fine-edged shark-tooth-blade with which the figure was carved.

I found this gem of our art collections—on a happy day—at a depth of not more than twenty inches, just between the overlying muck and the middle stratum of peat-marl, near the edge of the shell-bench—in section 15. Not far away were found, a large stool, a decayed mask, portions of a short wooden stave, and of symbolic ear-buttons ; a sheaf of about two dozen throwing arrows, and other remains of warrior- and hunter-paraphernalia and accoutrements. This affords convincing evidence that the statuette was a fetish or god of war or the hunt, like its clumsier stone analogues in Zuñi land.

Fig. 2 represents the finest and most perfectly preserved example of combined carving and painting, that we found—unless the figurehead of a great sea turtle and its companion masks, referred to on p. 89, be exempted. In form, or mere contour, it portrayed with startling fidelity and delicacy, the head of a young deer or doe, a little under life-size ; that is, in length, from back of head to muzzle, seven and a half inches ; in breadth across the forehead, five and a half inches. The view, as stated in the text, on p. 392, where the significance of this figurehead is discussed at large,—was an unfortunate choice for illustration, since it is in full front, instead of in profile or a three-quarter aspect. Certain points not noted in the text should be referred to here. Not only were the ears. the bases of which were hollow, or tubular—and as already

stated transfixed with pegs to facilitate attachment by means of cords passed through bifurcate holes at the back edge of the headpiece,—but they were also relatively large, and were fluted, and their tips were curved as in nature, only more regularly; and they were painted inside with a creamy pink-white pigment to represent their translucency; and the black hair-tufts at the back were neatly represented by short, double black streaks of paint, laid on lengthwise and close together. On the crown of the head were two slight, flat protuberances, with central peg-holes, for the attachment of small antlers, probably imitative, for they had disappeared, as actual horns would not have done.

The slime of the tortoise-shell eyes still remained in place, and the combined bees-wax and rubber-gum cement with which they had been secured was still intact when the specimen was found. The whites of the eyes had consisted of some very bright gum-like substance, and the front corners or creases of the eyes had been filled with black gum and varnish, highly polished, so that, save for the four conventional sets of equidistantly radiating winker-marks, they gave a surprisingly life-like, realistic and timid or appealing, yet winsome expression, to the whole face. The muzzle, nostrils, and especially the exquisitely modeled and painted chin and lower jaw, were so delicately idealized that it was evident the primitive artist who fashioned this masterpiece, loved, with both ardor and reverence, the animal he was portraying.

The face-markings were perfectly symmetrical. Those in white are sufficiently shown in the drawing. The cheeks or jowls were gray-blue, merging upwardly into black, and the two central and lateral bands over the forehead were divided by a deep black band, and were themselves of a deeper blue. The face, below the forehead-crescent, and between and to either side of the white nose-marks, was painted a dull black; while the nozzle was covered with an intensely black and gleaming varnish, and the nostrils, which were outlined in black, were deeply cut in and partially filled with a thick dead black substance, to make them appear still deeper.

I need only add that all the face-marks were not only delicately outlined with black, but were edged with fine, regular hair-marks; and that like marks, as well as minute stipplings, covered all the blue, and lighter black areas of the face and sides, while along, and to the rear, of the upper lip, the hair-warts were represented by neat, oval and regularly disposed, thick or protuberant dots of black gum or varnish.

Although so much of the line-painting on this figure was as fine as though made with a camel's-hair brush, it was evident, as on other painted specimens, that points and spatulæ of some kind—probably of wood—as well as brushes of human hair, had been employed in much of the work; for the paint was mixed thickly with gum-sizing,—such as we found many lumps of, in several shells filled with both the black kind, and with the less permanent white and blue kinds of pigment.,

Fortunately, we secured an excellent photograph of this splendid

specimen, in situ; and fortunately, also, it was immediately yielded to Mrs. Cushing's care. For she placed it, with a few other choice specimens, in a protected corner of our cabin, turning it and them, carefully, daily, so that they dried so evenly and slowly that they neither warped nor checked—only grew smaller in the process.

Fig. 8,—a, b, c, d, e, and f. The illustration here offered has been so fully referred to in various portions of the text, especially on pp. 393, 394 and 402, that little need be added.

While the central figure represents the art of the Georgia mound builders, the marginal figures (of warclub, *a*—described on p. 378); of plait-bound wrist-band and leg-band (*b*, *c*,—both painted in ventral valve of a sun-shell, described on pp. 386, 387 and illustrated in Fig. 4, Plate XXXIV); of large, inlaid, eye-like ear-button (*d*,—described on pp. 374, 375); and of mask and ear-plug (*f*,—respectively described on p. 375 and pp. 388 et seq.), are taken from objects and art specimens found by us in the Court of the Pile Dwellers, at Key Marco. The correspondence between them and the details and paraphernalia of the Georgia figure, is sufficiently apparent at a glance.

It is desirable, however, to indicate several other points of correspondence which might have been as clearly shown, given more ample scope of illustration. In fact, our finds in the keys,—carefully observed in their relations to one another,—actually furnish a nearly complete commentary or explanation, of almost everything portrayed in connection with this remarkable delineation of the ancient mound builders so skilfully rendered and accurately reproduced in Prof. Holme's drawing here given.

To begin with, the war-club we found was *practical*—a war-club for use; while the baton-like war-club held in the hand of the figure was ceremonial and decorative. Nevertheless, our specimen, like the one in the figure, was furnished with a knob at the end, grooved for the attachment of a tassel, precisely like the other one, conventionally shown in this figure; that is, the cord of attachment had been furnished, not with two, but with one, sliding-bead (similar beads of both shell and deer-horn were frequently found by us). The node below these beads had been formed by enwrapping a little conical plug of wood lengthwise and then around—in a manner quite familiar to our grandmothers, and shown clearly in the figure before us—and the fringe of the tassel had been made of combined yellow, and green, very finely twisted, sea island cotton cordage.

I have already commented upon the beads of the necklace worn in this figure. The pendant hanging therefrom, represents a typical form found in all the more northerly of the Florida Keys. It is made from the columnella and a portion of the spire of the busycon-conch-shell so common there. These large-headed, pin-like pendants, were not only used as such, on necklaces, but were also favorite ear-spikes and -pendants combined. When worn as ear-spikes, they were thrust through the

ears so that the polished conical plate formed from the spire of the shell, showed like a convex disc, in front.

The central portion of such a head-frontlet as is shown turned sidewise over the forehead of this figure, was found by me between sections 20 and 29, near the fine figurehead of an osprey or fish hawk. It consisted, not of four, but of six, slender yellow wooden slats, shaved as thin as cardboard, and lying side by side,—in which position relative to one another, they had been secured by fine threads, alternately woven over and under the slats, precisely as seems to be indicated in this primitive delineation. The slats that I found, however, had been figured over with black paint (and probably other colors), but the design could no longer be made out.

One other feature in this figure deserves interpretation in the light of our finds—the representations of *hair* on various parts of it. On such of our specimens as exhibited hair painting, the mode of representation was precisely such as that exhibited around, (1) the pointed flap at the hip of the figure; (2) on the cross-marked, semicircular band at the back of the head, as well as, (3) in the centre of the object that stands slantingly up therefrom; and finally, (4) on the tail-like tassel stiffly depending from the back of the head, as well as (5) over the crest of the hand-mask held below. All this makes it clear that (1) the flap in question, was that of a beaded and otherwise decorated girdle-pouch of *fur*; that the semicircular band (2) was a hair-crest, while the object (3) slanting up from it, was an elaborate hair-knot, attached to either side of which was a thin semicircular plate,—in this case, probably, of mica: for among the keys, silmilar, curious plates, were made either of gleaming pinna shell, or of rubbed down, and highly polished pecten shells; while in ancient Shawnee mounds, identical forms have been found, made, however, from the palmate portions of elk horns, and furnished with teeth or narrow combs, unmistakably to facilitate insertion into the hair. Finally (4) the dark tassel is simply a plaited scalp-lock or queue, the end cut off squarely, and the hair standing out, therefore, like the bristles of a much spread brush.

Yet other details in this and kindred figures of mound builder art, could be explained equally well by comparisons with our finds as observed *in situ*, but enough has been said, I trust, to render quite conclusive the close and actual relation, if not the identity, of our key-dweller art, with typical examples like this, of mound builder art—such relation as I have not hesitated to suggest in the text.

Discussion.

Dr. Brinton :

Mr. President :—After the brilliant demonstration of discoveries in an entirely new field of American archæology, to which we have been privileged to listen this evening, all that I could add is a discussion as to the probabilities of the builders of those remarkable remains being known or unknown to us. I shall review, briefly, the history, so far as we know it, and the ethnography, so far as we know it, of the localities in which these were found.

Columbus, in his first three voyages, did not hear of the Northern continent. He struck the Bahamas ; he was in Cuba ; he heard of the Southern continent ; he heard of Yucatan ; but he did not hear, apparently, of Florida. His last voyages were made from what he had learned from the Indians of Cuba as to where the mainland was situated. He went toward the south, as you know, and toward the west. He did not go toward the north. So far as we know the first information which was derived by the Spanish settlers of Cuba and the Antilles —their first information of the Northern continent—came somewhat later. It was probably twenty years afterward that they first made their expedition to discover what is now known as Florida.

The earliest exploration, which was that made by Ponce de Leon, he was distinctly led to make, according to the information we derive from his contemporaries, by reports of the Indians of Cuba. He went very nearly to this spot which has been shown on the map this evening and journeyed northward. What led him, according to the statements, was not only the thirst for gold but a nobler idea, the discovery of the fountain, the river, of perpetual life. It is a common belief, among the North American and South American Indians, that somewhere or other there is that fountain or stream. It can be explained by their general theory of mythology. No doubt it was shared by the Indians of Cuba ; no doubt he heard of that, and it led him, therefore, in part, to make his expedition. He carried it out with unfortunate results, so we have never been able to profit by the discovery in the sense in which he intended it. That was about 1512 to 1520—two expeditions which were sent out by him or under his charge. We have no very full reports of them, although we have some accounts.

On the other hand, we have abundant information of the expedition which was headed by Hernando de Soto, who reached the Florida shore in 1540. He landed also on the west coast of Florida, and probably in Tampa Bay ; most likely near the present town of Tampa. We learn from the accounts of that expedition that he discovered there tribes who were accustomed to build just such mounds as have been described to you this evening. Those mounds are still in existence, and, so far as we can locate the mound-builders, they were precisely where he pointed them out. The historians of his expedition say, "The natives

builded their houses on mounds made with hand for strength," as military positions, and in order to raise them above the waters which sometimes invaded them. We have, therefore, a distinct statement, which cannot be controverted, that at that time those people were accustomed to build just such structures as those which have been mentioned to you to-night.

From that time on the sources of our information are rather abundant. There was a Spaniard (one of many who had been wrecked on the Florida reefs) by name d'Escalante Fontaneda, who had been captured by the Indians and remained with them six or eight years, about 1552 to 1560. He lived to write an account of his explorations there. He said he had traveled all over the peninsula of fair Florida, and adds that he "had bathed in every river that he had come to, hoping that it would be the one to confer upon him perpetual life." He regretted to add that he had not found it, otherwise we should have had him here to-night.

He says of the people there dwelling that they "live in a condition of comparative simplicity, but are great warriors and fine archers." He adds that they were divided into a certain series of village communities; and he mentions one in particular where he stayed the longest time, about the locality described by Mr. Cushing. He gives us the name of the chief of the country, Caloosa; he tells us also that that had been a kingdom for many generations, and furnishes a few particulars as to the genealogy of the king; among others, the name of his father (Sequene) and the names of his ancestors. We have, therefore, rather strong evidence from this that the people who constructed these mounds belonged to a race who continued to live there for some time after the first discovery of the country.

From that time on Florida becomes a known country. In 1562, the Protestants, who had been sent out by Admiral Coligny, settled in the vicinity of the lower St. Johns, not far from St. Augustine. They remained there five years; wrote several very excellent books about it (which we still have, fortunately); when they were dispossessed and mostly massacred by the Spaniards who came in 1567. The Spaniards made a permanent settlement.

The French had gone far up the St. Johns River, probably to Lake Okeechobee. The Spaniards explored it quite thoroughly and their priests immediately began to study the languages and write books in them and instruct their converts in religion. We have not all those books, but we have several of them, so that we know something about the native tongues of Florida at that time.

I need scarcely pursue this branch of the subject further than to say that it was probably nearly a century before a Christian (Catholic) church was founded directly in the locality which has been described to-night. It was probably about 1660 or 1666 that the Bishop established a permanent priest there. He did not, however, have sufficient

means to extend his parochial duties very far; so that a chieftain of this very tribe went over to the Bishop of Havana in 1668 and asked for an additional priest. We have the record of that journey. He sent over with this messenger a written description of what he wanted, not written in the Spanish nor in Latin letters, but in characters which they were accustomed to use, somewhat similar, probably, to those four speech-words which Mr. Cushing has shown us to-night on one of these illustrations, some form of hieroglyph.

Now, how can we get at the evidence as to who these people were? We found, in the first place, the earliest discoverers meeting with tribes who lived upon mounds made in the manner described. They are not depicted in full; but the fact that they were mound-builders and mound-dwellers leads us to suppose that they might have extended to the Florida keys and also the Ten Thousand Islands on the southwestern coast. We have, I take it, the means to a solution through our linguistic studies. Hernando d'Escalante Fontaneda (the Spaniard whom I spoke of, who lived between 1550 to 1560 some five or six years in this very locality) has left us in his memoir some fifty or sixty names of the native towns, villages, chiefs and peoples. They have been very carefully examined by Mr. Buckingham Smith, with the aid of Mr. Pitchlyn (a native Choctaw), and they have, I consider, been practically identified by him as belonging to the Choctaw group of dialects. He has, it appears to me, sufficiently shown this. I will give you two examples out of a number Fontaneda tells us that one of the villages was called Cuchiyaga, which he translated "The Town of Weeping." Now Mr. Pitchlyn says this means in Choctaw literally, "Where we are going to weep." He gives us the name of the king, Caloosa. There is no doubt that is a Choctaw word. Fontaneda says that it means brave, or fierce, or cruel; Pitchlyn says Caloosa means "the brave black man," "the brave dark-colored man," dark or black being also the symbol for bravery, boldness, ferocity. We have, therefore, these two words, the meanings of which are given by Fontaneda, and which Pitchlyn says are good Choctaw to-day. I take it, therefore, that there is a very strong supposition that the inhabitants of southwestern Florida spoke a Choctaw dialect.

It is somewhat remarkable that we do not find any French or any Spanish early accounts, giving traces of the Choctaw in the vicinity of the lower St. Johns. That region was populated by an entirely different linguistic stock and people, the Timucuas. Their language has no similarity to any other, either in the Northern or Southern continent. It is absolutely extinct and was a century ago; but we have, fortunately, one grammar and a confessional in it, which have been lately published by the diligence of several eminent French scholars. We do not find the Timuquanan words on the west coast of Florida, except in the vicinity of Cedar Keys considerably to the north of the locality spoken of to-night.

Mr. Cushing has pointed out a similarity between the cultural elements discovered there and those in the vicinity of the Etowah mounds, where the particular design he showed upon the screen has been taken from. We know that the Etowah mounds were distinctly in the Choctaw country. I believe, therefore, that from the cultural side of the question we have evidence enough to say that the main dialect of southern Florida at the time of the discovery was Choctaw.

At the same time I desire to bring forward some evidence to show that it was not exclusively Choctaw culture. Our very eminent American archæologist, Prof. Holmes, has made a study of pottery throughout western Florida, in which he has shown that the decorations of that pottery are peculiar in character and have many similarities to what he calls the "Antillean culture," or the culture of the Great Antilles—Cuba and so forth. In conversation with him, however, he tells me that all the specimens on which he bases this are superficial finds; in other words, they lay upon the top of the mounds and village sites and are not ancient. He believes, therefore, that the influence of that culture arrived at a comparatively late period. The explanation of that I believe we can obtain from this same good old Spaniard, Fontaneda. He tells us in his memoir that the natives of Cuba used to come across the Gulf Stream and land in Florida in search of the fountain of life; and that they came finally in such numbers, that the king, Caloosa, or his father, Sequene, assigned to them a particular village in which they should live, telling them that it was useless to pursue that quest any further. No doubt he had looked for it himself, with disappointing results, and therefore he assigned to them a particular locality on one of these islands, and told them to live there. In all likelihood they brought with them some touches of Antillean culture, which explains the decorative designs of Prof. Holmes.

It is not likely that we can find any trace there of true South American culture. The only people who occupied the Great Antilles and the Bahamas and all the northern portion of the West Indies, were the Arawaks. There has been some question of Caribbean decorative designs; but the Caribs never extended their permanent settlements even to the island of Cuba. They were known there and Columbus first heard of them there, but they came merely as pirates; they plundered the shores and carried off women. These Caribs came rather late to the northern shores of South America. They have been traced in the last ten years in a manner which, I believe, is completely satisfactory to American scholars. They never constructed a single permanent village on any part of the North American continent; never anywhere north of the Isthmus of Panama; never in Florida or along the gulf. If so, we have no evidence of it whatever; it has perished utterly. As to the Mayas, Columbus distinctly heard of the Mayas in Cuba; his attention was called to them by the fact that the Cubans had wax, which they did not make from their native bees. It was the discovery of that wax in Cuba which led him to inquire and to ascertain that it came from the

Mayas at Yucatan. We know therefore that commerce between them once existed; and no doubt many elements of culture passed over from Yucatan to the western portion of Cuba. We cannot trace it now on account of the total destruction of the Cubans at an early period; and also because investigations have not been carefully made there for archæological purposes; but we know the facts; we know that the Mayas did extend to Cuba, though they had no permanent settlements there. The native languages in Florida—there are really only two so far as the original names are concerned—were the Choctaw and the Timuquanan. In the Antilles, in the Bahamas, and in the whole coast of South America from the mouth of the Orinoco eastward to the mouth of the Amazon, the country was covered exclusively by Arawak villages. They migrated from the south to the north. We can trace them back to the highlands of Bolivia, where their ancestral stock still remains. Their history can be followed linguistically and culturally from the central crestline of South America coming northward. They reached the West India Islands, probably, at no great time anterior to their discovery. It might have been 500 years, or 1000. We have not found on these islands any signs of culture, other than distinctly Arawak or Antillean in character.

It would appear, therefore, from these various lines of argument—historic, cultural and linguistic—that we can discern a distinct development, local in character, ethnic in its traits, of a North American culture. There are, to be sure, many strange points of similarity between that and the Central American and South American culture; but, as has been said by an eminent American archæologist, "Wherever you find the American Indian, you find him tarred with the same stick." He is always developing under ethnic conditions towards a culture which is similar everywhere. That is shown in many instances where we come to study out any Indian development. Take this one of masks; if we compare the general character of those masks with those which we find elsewhere (still preserved in actual use) we find a similarity in the traits of them all. American culture is in one sense everywhere the same. It is everywhere the same in its origin and in its lines of development, although they are deeply influenced by ethnic and local peculiarities.

I do not think the culture which has been exhibited here to-night—strange and remarkable and most instructive as it is—has any peculiarities which are in themselves broadly distinct from those in the Choctaw district of northern Georgia and in the mounds there. Hernando de Soto, when about 1540 he made that exploration, found an extremely high state of native civilization throughout northern Georgia. He passed through that region where we find now the Etowah mounds; he found people there who knew something about the use of gold and silver and who were in what we might call a copper age; and he encountered a people so highly developed that the historians who accompanied him all expressed their admiration at it. The

remains which have been discovered since confirm those reports; so I believe that the culture described this evening, which is eminently a maritime culture, has developed from the same centre, though in its own direction, and has many analogies to the culture which Hernando de Soto found some distance north of it.

We have a record—very unsafe to follow—composed about 1650 to 1658 by an Englishman, written in Latin, translated in French and published in Rochefort's *History of the Antilles*, where the writer says that a general art culture existed from the Appalachean country southward; and he tells us, as Prof. Mason has pointed out, of dwellings built on piles in the lower portion of Florida. I have not myself examined the original since I saw Prof. Mason's quotation some months ago; but I think it very likely, that pile dwellings are found anywhere among native tribes where it is convenient to make them. We meet them throughout Borneo and Maracaybo; and to this day the Seminoles, who live in southern Florida, build their houses often on piles in the bayous. It is one of those natural and necessary methods of construction which we will find under certain geographic conditions wherever they are discovered. This is my contribution to this most interesting study—entirely novel and extremely valuable—to which we have had the privilege of listening.

PROF. PUTNAM:

It is seldom that an archæologist has the opportunity of examining a collection of objects of so much scientific importance as those on exhibition here to-night; and it is certain that a thorough study of all the results of this exploration, carried on by Mr. Cushing, under the auspices of the University of Pennsylvania, will add largely to our knowledge of American archæology.

Dr. Brinton has expressed the opinion that the people represented by this collection were very likely of the same stock as those in other parts of Florida and Georgia. I fully agree with him on this point, because the culture we have here is of the same type as that known to have existed in other parts of Florida, and in Georgia, and I may say that it is similar to that still farther north, as far up as the Ohio valley.

What I consider the most important point in Mr. Cushing's discoveries is that he was able to bring out of this muck deposit on the Florida Keys a large number of objects which by being buried in the muck were preserved; whereas the same objects if buried in a sand mound or lost in a shell heap would have perished. It is important to note that the objects in this collection, made of imperishable material, such as stone, bone and shell, are of the same character as those already known from other parts of Florida. Thus it seems to me that Mr. Cushing's discovery instead of indicating a new culture, has thrown a powerful light upon, and greatly extended our knowledge of, the old culture of Florida.

The question we are all asking is, Where did this people originate?

Mr. Cushing is inclined to believe that they came from South America. I understand that would be your idea (turning to Mr. Cushing), that these were the Arawaks or the Caribs, and that they came up from South America?

Mr. Cushing (answering): Yes.

Prof. Putnam (continuing): Dr. Brinton is rather inclined to say that they did not come from there.

Dr. Brinton: Because there is no linguistic evidence to that effect.

Prof. Putnam: And also that the culture is somewhat different from either the Arawak or the Caribbean. It seems to me that it certainly is a different culture. And now there is another point that we must consider. Mr. Cushing's collection includes a large number of human skulls which I have had the pleasure of seeing in the museum today. I am much interested to note that these skulls are of the same type as those found in the sand mounds of Florida. The first of this type that I ever saw came from the sand mounds around Cedar Keys and were brought to notice by the late Prof. Jeffries Wyman. Mr. Clarence B. Moore has found this type in the sand mounds of eastern Florida. The same general type has been found throughout northern Florida, Georgia, Alabama, and through the region extending towards the Cumberland valley in Tennessee; also westward through the Pueblo region and in Central America. It is the general brachycephalic skull; not only brachycephalic, but decidedly rounded, with more or less artificial flattening of the frontal and occipital regions. I have regarded this type of skull as belonging to the southern and southwestern peoples of North America. I believe that this type of skull is the type of the people who first settled, so far as we know, in Central America and on the shores of Peru and northern South America; that in all probability this people extended eastward, coming across the Isthmus through the Central American region and extending along the Gulf of Mexico and over into Florida, and finally, judging from the evidence that Mr. Cushing has presented to-night, being driven onto these keys. In fact I should consider it probable that the line of migration was directly opposite to the one which has been suggested. That is, I believe it more likely that this was a people who, having had an early home in the Central American region, extended around the Gulf to Florida, rather than a people who came from South America to the Florida Keys and then spread into Florida and westward.

For a number of years Mr. Clarence B. Moore has been engaged in exploring the sand mounds of Florida. He has found a large number of objects of the same character as many of these upon the table. He has not found any wooden carvings; I think he has not found anything made of wood except a few very small pieces with copper attached; but nearly all the bone implements, many of the bone ornaments, and many of the shell implements which are upon the table are almost identical with those found in the sand mounds on the eastern coast of Florida. Thus we find the same culture, so far as the bone and shell objects can

determine the question, which existed here on the southwestern coast of Florida, extending northward up the eastern coast.

The wooden objects in this collection are very remarkable; and the fact that wooden vessels took the place of pottery is an important one, as it seems to indicate that the people were forced to use wood instead of pottery from the abundance of the former and the absence of clay to make the latter. These masks I consider the most marvelous archæological evidence that has ever been brought out. Never before have we been able to dig up masks and to read the story that they tell as Mr. Cushing has read it to us to-night. We know that the people of to-day in Central America use masks very similar to these; and I believe that the people of South America have somewhat similar masks. We know that many of our Indian tribes have masks of very similar character. This form of mask having the characteristics of the bird, or some animal, represented over the face is so common to-day in Alaska and other parts of the northwest coast, that it is actually startling to an ethnologist to see these masks, dug up in Florida, showing the same character of art. The interpretation that Mr. Cushing has given to this idea of expressing the animal upon the human face and of making the Bird God, or the Wolf God, is the same as that worked out by Dr. Franz Boas; and this we know to be true from actual evidence of the Indians themselves.

I can only add that when I read Mr. Cushing's first statement of this very interesting discovery, I did not know what to make of it. It seemed to me almost beyond belief that so much of importance could have been found down there in Florida, where so many had been working. From his statement and from the photographs which he has shown us to-night I am satisfied that he has entered upon a very rich field, and one of the utmost importance to the archæology of North America. I sincerely hope that his work will be continued, that he will have an opportunity to return to this place, and, if possible, to work for several years about these keys. This whole subject should be investigated in a thorough manner, that we may understand still more of this people who built these peculiar and wonderful shell structures. We do not begin to appreciate the probable antiquity of this people until we stop to consider that these Florida keys could not have supported a very large population, and that it must have taken an immense amount of time and millions upon millions of conch shells to make these great mounds, upon which the dwellings of the people were probably erected. Mr. Cushing states that this people must have lived upon these keys many centuries (I am inclined to say many thousand years) ago.

There has been presented to us to-night one of the most important archæological papers that I have ever listened to; and certainly the objects illustrating the paper are of extraordinary interest.

I sincerely congratulate Mr. Cushing, as well as the University and all connected with this expedition, on the important results of his labors.

Mr. Cushing : If I may be permitted, Mr. President, to follow an address, already so long, with a few remarks in reply to the most interesting discussion with which Dr. Brinton and Dr. Putnam have at once honored me and added greatly to the value of my communication, I shall much esteem the privilege.

The President :—The Society will be pleased, I am sure, to listen to further remarks from Mr. Cushing.

Mr. Cushing :—First, then, in reference to Dr. Brinton's part in the discussion, let me say that it was quite impossible for me to undertake to review, much less to dwell upon, the numerous historic references to early natives in Florida, that seem—as I am well aware—to have pertained to the waning days of a people who were either the actual key dwellers—as I have called them—or were certainly inheritors, in great part, of their culture. Could I have done this, Dr. Brinton would have perceived that my belief fully,—almost more than fully—accorded with his own, regarding the affiliations of these people with later and historic peoples. I would add, relative generally to the early inhabitants of western, southern-central and southwestern Florida, that from archæologic evidence alone, one can scarcely doubt they were, at the time of the discovery, chiefly Maskokians (or of the stock to which not only the Muskhogees, but also the Choctaws or Chahtas, the Hitchiti and other tribes of the Creek Confederacy, of the Southern States, belonged,—as, if I remember aright, Dr. Brinton long ago pointed out in one of his published works. And since I regard these Southern mound-building Indians as having inherited their mound-building habits and much of their culture otherwise, quite directly from key dwellers, I of course believe, with him, that the key dwellers themselves may be looked upon as having been, during the later centuries of their existence, not only American Indians, but North American Indians, and thus, in a racial sense, by no means a new people.

After all, the chief significance of these discoveries and finds of ours in the keys of southwestern Florida is to be found, as I have said before, in the unique illustration they afford of a peculiar local development in culture and art as influenced by, or related to, a peculiar environment; and in this, while they may not pertain to a new or hitherto unknown people, they certainly do reveal either a new *phase* of human culture, or else an old culture in an entirely new light.

Nevertheless, I wish to explain a little more explicitly, quite exactly where I stand with regard to these ancient key dwellers of mine—as to who they were more remotely, as to what may have been their origin! It is true I do not believe—and I do not think I have anywhere stated the belief—that they were a *new people*, or even that theirs was wholly a new culture. I admit that there have appeared various articles in which the most extravagant announcements have been made relative to my Florida discoveries,—such announcements as I would not for a moment have encouraged the statement of; and even in what I myself

have written for the press, I cannot be held responsible for "headings" or "editorial leaders,"—much less for comments thereon in the press at large.

But I would repeat that I think a close study of many objects in our collection reveals decided trace of survival in art-types of a kind which cannot be accounted for as well otherwise, as by supposing it to have been derived, inherited remotely, I should say, from farther southern regions—from South America, in all probability. In my spoken address I did little more than touch upon this important point, in order merely to bring it before you in the proper connection, and I may not have stated clearly enough that I did not think the key dwellers themselves, or as a people, were wholly South American. I think, however, that they may have been such in the very beginning; that a South American people, or that an intermediate sea-dwelling people derived thence, and coming at last on the currents of the Caribbean Sea, to the region of these keys—as indicated by my map—initiated, in this region, the practice of the key building of which I found so many evidences. I have already referred to the pointed paddle we found, which is both South, and Central American, in type; to the absence of bows, and the presence of atlatls, which are likewise at home in those remoter regions, more so than in these: and to the type of war club which prevails down there, and of which, in particular, I would, even at the risk of repetition, say a little more in this special connection. Let me exhibit to you the actual specimen we found. It is, as I was at considerable pains to show you, Maskokian in type, of the southern mounds; or, as Dr. Brinton has assured you, Choctaw, which is practically the same thing. But the specimen I hold in my hand is an actual weapon, not merely ceremonial, as were those of the Southern Indians, and it is distinctively South American in type. It is not, save in semblance, such as its parents were. It is wholly of wood, yet it does not represent survival from a club of wood alone. It represents, if I am not mistaken, survival from a form of weapon like the double-bladed battle axe, peculiar, originally, to South America—a form derived from a type of stone-bladed implement nowhere represented in North America. I here refer to the short, broad, and round-bitted, flat-backed celt-blade, sharply notched at the sides near the butt,—not grooved as are the axe blades of the United States,—which anciently prevailed all through the Bolivian Highlands, in Peru, Ecuador and along the upper reaches of the Amazon, and thence spread, no doubt, not only northwardly into the Isthmus, but also northeastwardly down the Amazon and the Orinoco. These blades were set oppositely, not into, but *against* the sides of their club-like handles, and were attached thereto by means of criss-cross bindings alternately passing through the right notch of one blade, obliquely across the handle, and through the left notch of the other blade, then through the right notch of the second blade, again across the opposite side of the handle, and through the left

notch of the first blade, in such wise that a weapon exactly resembling this one, in general outline, was produced. From such a form of weapon the double, semicircular bladed battle-axe of copper or bronze which prevailed at the time of the Conquest in both Peru and Isthmean, or Meridian America, appears also to have been derived; as well as the form of club I have described and here shown to have been almost as characteristic of the keys (and, ceremonially, or still further derivatively, even of the southern mounds) as it was originatively, of the country of its nativity, namely, South America.

Much of like import may be said of the plaited leg-bands represented on the human figure painted in the shell I have exhibited and described. These bands are drawn as passing around,—not the ankles, as at first sight appears,—but around the legs, just below the knees and above the calves; and we know that both the Arawaks and the Caribs had the curious practice of tightly bandaging the legs in this fashion, in order, it is alleged, to enlarge the calves: but whether this is so or not, we see that the practice was typically South American; and I may add that it prevailed nowhere in Northern America except apparently here among the keys and in the mound region, and that in this last, it was evidently a survival; for it may be seen that the mound plates, such as I have shown you by illustration, represent figures wearing not only wristlets and leg-bands, as in this painting,—and as worn by the South American and Antillean Indians,—but also, armlets or bands *above* the elbows, and anklets or bands *below* the calves, as worn by so many central North American Indians, when first encountered.

Now I have mentioned these comparatively inconspicuous characteristics, not simply because they are the only evidences that might be adduced in support of my supposition, but because they are the readiest at hand and the most easily illustrated, of many such evidences.

I have not been unmindful of the fact that Prof. Holmes pointed out, some years ago, an apparent Caribbean element in the decoration of certain ancient Floridian potteries, and although I surely referred to the subject in the course of my address, I evidently did not make its significance as clear as I trust my published notes will render it. Meanwhile we are certainly off of debatable ground when we study or consider the collections of pottery made by us in the northerly portion of the State, —at Tarpon Springs,—or those made by Mr. Clarence Moore in easterly portions of the State (as compared, in various ways, with the collections of corresponding wooden-ware vessels gathered by us from the southern keys) in reference to their relationship to primitive art-technique and symbolism; as influenced by, and inherited from, a given environment.

The forms of these terra-cotta vessels, and particularly the decorations upon many of them, were eloquent of at least one thing,—that their types had originated among a people who had once,— ignorant of pottery-making,—made their vessels of shells, of simple gourds, and of wood; and that those primitive vessels of theirs had been more or less

like unto these, their later vessels in clay. For, by critically examining the peculiarly involuted and concentric designs on so many of them, such as were recognized by Prof. Holmes as analogous to Caribbean decorations, I find that they were undoubtedly derived from the natural markings of the curly- or crooked-grained wood of which these ancient peoples had earlier made their principal vessels—that is, before they became makers of pottery vessels at all.

Again, what lends plausibility to this supposition, is the fact that in much of the pottery under consideration the surface-decoration resembles a hachuring—so to call it,—the origin of which is as unmistakably traceable to the surface markings of wooden objects carved with shark-tooth blades; and is simply the reproductive or imitative perpetuation, in clay materials, of such markings as were unavoidable in vessels thus made of the wood materials that preceded the use of, and served as the models for, these vessels so differently made of pottery materials. All this would, to my mind, indicate that these forms of decoration,—Antillean as well as Floridian—owed their origin to a similar condition and environment,—and thus very probably were derived from some common source.

I failed, it now appears, to consider sufficiently these and many other points which have been so appropriately brought forward and emphasized by Dr. Putnam as well as by Dr. Brinton, because, as I early stated, it seemed necessary for me, in order the better to exhibit and explain the large number of lantern slides (there were sixty-seven of them) to abandon my manuscript notes. From the scientific standpoint I ought not, in justice to my subject, to have done this, and I now regret that I did; for in the outline or syllabus of the address which I furnished to both Dr. Brinton and Dr. Putnam these points were at least indicated; and in my manuscript, as will appear when it is fully published, nearly all of them were fairly set forth.

If, then, you will permit me to restate my conclusions on one or two only, of the more general of these points, which seem to me to include or imply so many of the others, I will not detain you longer.

I cannot express too strongly my belief that there was a large "Muskhogian" (or Maskokian) element among the ancient inhabitants of western Florida—so large, in fact, that I think we may justifiably map the whole western half of Florida, to as far south as the very end of the peninsula, as *Maskokian*. Now the Maskokians were mound builders, and therefore, according to my theory, must long have been dwellers in the land. Whether they had themselves come from the South, or whether they came thither from the North, or whether, as has seemed to me more probable, they resulted from an intermingling here of stocks from both directions, these questions still remain, I think, to be determined principally by further archæologic researches of precisely the kind of which I have given you some account this evening,—although much more extended, for I have but entered the borderland, as it were, of

an enormously large and fertile field. But I must reiterate that in the keys, in the essential features thereof, and in the principal structures thereon, we have prefigured, as it were, the mound-groups and their outworks—those built not only by the Maskokians and other historic Indians, but also by the prehistoric so-called mound builders themselves; and since the keys thus represent a kind of mound building that was absolutely essential, while to account for the almost equally laborious earth-mound works, practical necessity cannot be conceived of as a primary cause, I have claimed, not that the mound builders were as a whole derived from the particular key dwellers I have been describing, but that mound building as practiced by them, was derived from an analogous sea-, or shore-land environment. And thus, too, I have ventured to suggest that the resemblance between the mound-groups of our own land, and the foundation-groups of ancient Central American cities—the plans of the principal structures of which are so strikingly like even the plans of the earlier key structures—may indicate that these, no less than the mound-groups themselves, were developed (with much else in ancient Central American culture) from an original sea environment of the same kind. So, the main point of all I have brought forward in relation to our discoveries and collections as representative of the ancient sea dwellers, is this: That for the study of *beginnings*, alike of the sort just named, and in technology and art, they are exceedingly suggestive and in some respects quite sufficiently conclusive.

In thanking the distinguished gentlemen who have so honored me with their discussion and in thanking the members of this Society for their patient attention throughout, I wish once more to acknowledge my profound appreciation of the aid and encouragement I have received from your distinguished Vice-President, Dr. William Pepper; my gratitude also to Mrs. Phebe A. Hearst, and to other members of the Board of Managers of the Archæological Association of the University of Pennsylvania, who made possible the investigations of which I have given you account this evening. Had they not thus come forward, I had personally missed an opportunity of enriching my experience in American archæology and ethnology that I have come to feel I could ill have afforded to spare.

[Since the remainder of this discussion consisted chiefly of a detailed description (occupying nearly half an hour) of the specimens and illustrations displayed in the Hall of the Society, I have not hesitated to incorporate the substance of the stenographic notes of it that were kindly furnished me by the Secretaries of the American Philosophical Society, in the body of the published address.

In justice as well to my two distinguished critics, as to myself, however, I must repeat that in the off-hand address which alone they discussed, I may not have made—probably did not make—a number

of the points they consider, as clear from my side as they were in my written notes, and as I trust they now are in the fuller text. Hence, it is not only appropriate, but seems to me a duty, to here furnish comments on three or four of these.

Regarding Dr. Brinton's reference to the mounds on Tampa Bay, I find, from the notes of the discussion, that I did not give the subject sufficient attention. I should have stated more fully, that the mounds which have been identified as those discovered by De Soto, were of precisely the kind I have described as occurring on Pine Island. That is, they are not true keys, for they are situated on the mainland, and they are composed of earth and shell combined, as were all the mounds near the gulf coast of Florida that I have described as probably the works of the descendants or successors of the key dwellers proper. True typical shell keys, no fewer than five of them, occur along the Manatee, below the opposite or southward side of Tampa Bay, but these are quite certainly not the mounds referred to as occupied at the time of De Soto. They are either islands, or contiguous to islands. Nevertheless one of them was apparently connected with a later series of earth-works which seem to have been subsidiary, like those of Pine Island, Naples and the Caloosahatchee region. It was in the region of these latter, and of the Okeechobee, that the renowned Chief Sequene and his successors, rulers over the Caloosas, held sway, and it was principally among these people—far inland, and more than a hundred miles northeastwardly from the Key Marco region, that Fontaneda seems to have lived. That the particular peoples mentioned by him were not the same as the key dwellers proper—certainly not the same in period and degree of development—may be inferred from the single fact that they were, as Dr. Brinton quotes, "fine archers;" whereas, I have shown that the true key dwellers were not possessed of the bow at all, but used atlatls and throwing arrows instead, and were not unacquainted, apparently, with the blow gun,—both, I may remark, distinctively South American types of weapon. That they derived these and other things already described, from the Arawaks of a period sufficiently remote to allow time for their domestication—so to say—in this region, still seems to me probable.

While there is much to indicate the comparatively recent introduction into both the Antilles and Florida of the Caribbean element, it seems to me almost certain that if, as is generally affirmed, the Arawaks were the true aborigines of the Greater Antilles, then they must have reached those islands much more anciently than Dr. Brinton is inclined to allow, —for some of the cave remains already found there give positive indication of high antiquity. Again authorities disagree as to the linguistic evidence of Antillean—Carib and Arawak—connection with the natives of southern Florida. An impartial examination of published and unpublished vocabularies convinces me that there is quite as much to prove such connection as has been brought forward to prove Maskokian con-

nection, the number of correspondences between the Arawak and the Timucua and between the Timucua and Maskoki, being, for example, about equal, and quite as readily explicable in both cases on the score of acculturation or borrowing, as on that of descent. It is for this reason that I have regarded archæologic evidence on this question of connections, as equal to, and in some ways superior to, linguistic evidence; and a combination of the two kinds of testimony as superior to either. When, for instance, we find that the same word in both Carib and Timucua signifies not only "Fish-pond" but also "Vegetable garden," and when we consider this in connection with the evidence I discovered on all the ancient keys, of the actual filling in of fish-ponds or enclosures to form of them vegetable gardens, it seems to me we have quite strong indication of a wide-spread practice, commonly derived, by all these peoples.

If the linguistic evidence relative to connections either toward the north or toward the south, of the ancient key dwellers, is thus far so scant as to be inconclusive, this is to a certain extent also the case with the evidence afforded by the human remains we collected. In justice to Dr. Putnam I must state here that the series of skulls in my collections, examined by him, were not the key-dweller skulls. They were skulls derived from the Anclote region, and like those he mentions as previously collected by Dr. Wyman and Mr. Clarence Moore, were exhumed from sand mounds. The true key-dweller skulls found by us in the muck beds at Marco and in the bone pit on Sanybel Island, number only thirteen, but they are pronounced to be, by Dr. Harrison Allen, who is studying them preparatory to full publication, uniformly distinct from those of more northerly and easterly parts of Florida. In the first place, the occipital foraminæ of these remarkable skulls are abnormally large and remain *open* in even the most mature of them,—a characteristic seen in only one cranium of our northern series. In the second place, a curious feature of all these key-dweller skulls is that in no case is the occiput flattened. Finally, they are found to be more nearly of the Antillean type, judged, it is true, by only one or two specimens of the latter examined by Dr. Allen, than of the northern Indian type.

In connection with this, it is significant that the skulls of two dogs, in our collections from the muck, were commented upon by the late Prof. Edward D. Cope, as apparently, almost certainly, skulls of the species of dog common in Incan times to the Peruvian and Bolivian Highlands.

Likewise in justice to Dr. Putnam, I must again state here that while there *was* pottery not only on the terraces, but also in the muck deposits, of the keys, even of the southernmost keys I examined; still, the specimens I exhibited before the Society—three in number—so closely resembled the wooden objects of the same general kind, also exhibited and in greater number, that they may well have been mistaken for vessels of wood unless particularly dwelt upon. It is a curious fact that of all the pottery discovered by us actually in the muck deposit of

Key Marco, only tray-shaped vessels, and either shallow, or hemispherical and deep, sooty, cooking-, or heating-bowls of black earthenware, were found. Nearly all, as was to be expected, were crushed; yet from among the numerous sherds carefully saved in lots, Mr. Bergmann and I have succeeded in bringing together the parts of not fewer than fifteen examples, of various sizes; and we hope to restore yet others. One small, shallow bowl, a fragment of which I exhibited to the Society, has happily been almost completely restored. It contains a quite thick mass of black rubber gum—intermixed with crushed shell and other substance—of precisely the kind that was used for cement and paint material as described in the text. Other and larger examples contain almost equally thick coatings of partly charred food, inside, and like all the rest, incrustations of soot, outside.

No relics found by us in the muck so completely evidenced the use of the water courts in which the deposits occurred, as places of actual residence, as did these fire-vessels.

Only a single ornamental fragment was found. This was the conventional figurehead of a crested bird, quite such as is found on many of the traylike bowls of earthenware from the ancient mounds of the Mississippi valley. But it had been drilled and reshaped, to some extent, to serve as a weight or pendant. On the contiguous heights, however, and on the heights of nearly all the keys, especially towards the North, I collected many examples of more elaborate, more decorative and varied pottery, much of it so distinct, in truth, from the pottery of the muck, that I was somewhat puzzled to explain it as the work of the same people, at least in the same period of their development; and, indeed, it may be that in part this pottery of the heights *is* later, and even perhaps represents to some degree the work of later peoples.

I can only add here more deliberately than was possible, of course, in my spoken address, an expression of my continued appreciation of the kindly comments with which Dr. Brinton favored me, and with which Dr. Putnam both opened and closed his discussion.]

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